This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

31.
148.

600005966W

E. J.K 1832

A BRIEF INTRODUCTION TO ASTRONOMY,

BY WAY OF QUESTION AND ANSWER;

WITH

A FEW USEFUL PROBLEMS ON BOTH GLOBES,

AND

COPIOUS EXERCISES.

For the Uſe of Schools and Private Students.

BY GEO. LINDSAY,

Teacher of English, Geography, and History, &c. &c.
26, George Street, Edinburgh.

BODLEIANA BIBLIOTHECA

SECOND EDITION,
GREATLY IMPROVED AND EXTENDED.

EDINBURGH:
SOLD BY
WM. WHYTE & CO., OLIVER & BOYD, AND JOHN BOYD;
M. OGLE, GLASGOW; JOHN SINCLAIR, DUMFRIES; JAS.
DEWAR, PERTH; A. BROWN & CO., ABERDEEN;
AND K. DOUGLAS, INVERNESS.

1831.

148.

Oliver & Boyd, Printers.

CONTENTS.

Page

Astronomy, Descriptive and Physical,........................... 5
The Sun,.. ib.
The Planets,... 8
Of the Motion of a Planet, and its Cause,.......................... 9
In what Time the different Planets would fall to the Sun by the Force of Gravity,.. 11
Mercury,... ib.
Venus,... 12
The Earth,... 16
Of the Figure of the Earth, and its being nearer the Sun in Winter than in Summer,.. 17
Circles, Great,.. 19
———, Small,.. 21
Latitude,.. 22
Longitude,... 23
Equinoxes and Solstices,... 24
Length of the Day at the Equator and the Poles,..................... 26
Zones,... 27
Moon,.. 29
Eclipses of the Moon and Sun,.. 31
Of the Harvest Moon,... 32
Direct, Stationary, and Retrograde Motions of the Planets,......... 35
Inferior and Superior Conjunction,................................... 36
Mars,.. ib.
Asteroids,... 38
Of the Origin of the Asteroids,...................................... ib.
Jupiter,... 43
———'s Satellites,.. 45
Saturn,.. 46

Page
Saturn's Rings, ... 47
——'s Satellites, ... ib.
Georgium Sidus or Herschel, ... 48
—— Satellites, ... 49
Comets, ... 51
The Fixed Stars, ... 53
Nebulae, or Small Clusters of Stars, ... 55
Constellations, ... 57
——, Zodiacal, ... 58
——, Northern, ... ib.
——, Southern, ... 59
Right Ascension and Declination of some of the most eminent Fixed Stars in the Constellations, ... 61
Tides, ... 62
Terrestrial Gravity, ... 70
Atmosphere, ... 72
Winds, ... 80
Of the Sea and Land Breezes, ... 82
Of the Monsoons, ... 83
Of the Velocity of the Winds, ... 84
Refraction, ... ib.
Twilight, ... 87
Precession of the Equinoxes, ... 89
Equation of Time, ... 91
Leap Year, ... 94
Problems to be solved on the Terrestrial Globe, ... 99
—— to be solved on the Celestial Globe, ... 107
Explanations of Terms made use of in Astronomy, ... 111

A
BRIEF INTRODUCTION
TO
ASTRONOMY.

OF ASTRONOMY.

Q. WHAT is Astronomy?

A. It is that science which explains the nature and motions of the planets, comets, and fixed stars; the various phenomena which these bodies exhibit, and the laws by which their motions are regulated.

Q. How is Astronomy divided?

A. Generally into two parts: namely, 1. *Descriptive Astronomy*, containing an account of the phenomena of the planets, comets, and fixed stars. 2. *Physical Astronomy*, containing the theory of the planetary motions.

OF THE SUN.

Q. What is the SUN?

A. By some it is supposed to be a large ball of fire.

Q. What is the opinion of DR HERSCHEL respecting it?

A. He regards the bright surface of the Sun as luminous clouds floating in the solar atmosphere.

Q. What does he consider the dark spots to be?

A. He considers them as the *opaque* body of the Sun appearing through the atmosphere in consequence of the removal of part of the luminous clouds.

Q. Does not he imagine, that below these self-luminous clouds there is another *stratum* of clouds of inferior brightness?

A. Yes; and he supposes it to be intended as a curtain to protect the solid and *opaque* body of the Sun from the intense brilliancy and heat of the luminous clouds. Hence it appears that the Sun consists of a dark solid *nucleus*, surrounded by two *strata* of clouds.

Q. What does the Doctor conceive the *outermost* of these to be?

A. He considers it to be the region of that light and heat which are diffused from the centre to the remotest parts of the system.

Q. What is his opinion respecting the *interior stratum*?

A. It is supposed to protect the inhabitants of the Sun from the fiery blaze of the stupendous furnace by which they are surrounded.

Q. Where is the Sun situated in the system?

A. Nearly in the *centre* of the orbits of all the planets.

Q. What is his diameter?

A. Eight hundred and eighty-three thousand two hundred and ten miles.

Q. What is his circumference?

A. Two millions seven hundred and seventy-four thousand six hundred and ninety-two miles.

Q. How many motions has the Sun?

A. He has one round his *axis* from *east* to *west*, in twenty-five days six hours, as is evident from the spots seen on his disc.*

Q. Has he any *circular* motion?

A. By comparing the proper motions of the fixed stars, DR HERSCHEL has discovered that the whole system is advancing to the *constellation Hercules*, or to a point in the heavens whose right ascension is 250° 52′ 30″, and whose polar distance is 40° 22′.

Q. What does he suppose this motion to be?

A. He supposes that this motion is performed round some distant centre, and he has endeavoured to determine its velocity.

Q. What does he suppose its velocity to be?

A. He conceives it to be equal to that of the Earth in its orbit, which is sixty-eight thousand miles an hour. But many ages must elapse before this inquiry can be crowned with success.

---

* In 1799, Dr Herschel perceived a spot on the surface of the sun which was about fifty thousand miles in diameter, which is more than six times the size of our earth. The *solar* spots, when observed for several days successively, seem to move across the body of the sun from east to west. When a spot begins to be seen on the eastern *limb* of the sun, it appears like a thin black line; but as it advances towards the centre of the disc, its breadth gradually increases, and it again diminishes as it approaches the western limb. This may be easily imitated by placing a black spot on a common globe, and observing the variations it undergoes while the globe is revolving on its axis.

OF THE PLANETS.

Q. What is a planet?

A. It is a *moving star.*

Q. How many kinds of planets are there?

A. Two; *primary* and *secondary.*

Q. What is a primary?

A. One that revolves round the Sun, as the EARTH.

Q. What is a secondary?

A. One that revolves round a primary, as the *Moon.*

Q. How many *primary* planets belong to the system?

A. *Eleven;* MERCURY, VENUS, THE EARTH, MARS, VESTA, CERES, PALLAS, JUNO, JUPITER, SATURN, and the GEORGIUM SIDUS or HERSCHEL. Those four, between the orbits of MARS and JUPITER, called the *Asteroids*, have been recently discovered.

Q. Which is the planet nearest the Sun?

A. *Mercury.*

Q. Which the most distant, or the highest in the system?

A. The *Georgium Sidus* or *Herschel,* which is likewise called *Uranus.*

Q. How many secondary planets belong to the system?

A. *Eighteen;* of which the Earth has *one,* Jupiter *four,* Saturn *seven,* and the Georgium Sidus *six.*

OF THE MOTION OF A PLANET, AND ITS CAUSE.

Q. What do you understand by a *rectilineal* motion?

A. It is this, that all bodies, if there were nothing to prevent them, would move in *straight lines*.

Q. Whence arises the *curvilineal* motion of the planets?

A. It arises from the uniform *projectile* motion of bodies in straight lines, and the universal power of attraction which draws them off from these straight lines.

Q. Why would a body projected along a straight line, in open space, where it would meet with no resistance, nor be turned aside by any other power, go on with the same velocity, and in the same direction?

A. Because the same force that *impels* it through any given space, in any given time, would make it go through as much more space in as much more time, &c.

Q. Would a ball, if projected into the open air, continue to move in a straight line, and with the same velocity as was at first impressed upon it?

A. No; for the resistance of the air would retard its progress, and the force of gravity would bring it down to the Earth.

Q. Whether do those planets that are near the Sun move quicker or slower in their orbits than those that are more remote from him?

A. They move quicker; all bodies moving with greater velocity the nearer they are to the power that attracts them.

Q. In what direction do the planets move round the Sun?

A. They all move from *west* to *east*, both in their *circular* and *central* motions.

Q. How are the planets retained in their orbits?

A. By the exact adjustment of the attractive power of the Sun, which draws all the planets towards him, and the projectile force of the planet, which gives it a tendency to fly straight forward.

Q. What is meant by the *orbit* of a planet?

A. The path which it describes in moving round the Sun is called its orbit.

Q. In what sort of orbits do they move?

A. They all move in *elliptical* or *oval* orbits.

Q. How is the *ellipsis* produced?

A. By the attractive power of the Sun overcoming, in some measure, the projectile force of the planet, by which the planet is drawn nearer to the Sun in one part of its orbit than in another.

Q. How comes it, then, that the power of attraction, when once it has got the better of the projectile force, does not bring the planets nearer in every revolution, till they at last fall upon and unite with him?

A. As all bodies move with greater velocity the nearer they are to the power that attracts them, so the planet, moving quicker in that part of its orbit which is nearer the Sun than in that which is at a greater distance, gives it such a tendency to fly off as overcomes the Sun's attraction.

In what Time the Planets would fall to the Sun by the Power of Gravity.

Q. In what time would the different planets, by the force of gravity, fall to the Sun, if the *projectile* force were destroyed?

	Days.	Hours.		Days.	Hours.
A. Mercury in	15	13	Juno, .	354	17
Venus, .	39	17	Vesta, .	205	0
The Earth,	64	13	Jupiter, .	765	19
Mars, .	121	10	Saturn, .	1901	0
Ceres, .	297	6	Georgium Sidus,	5425	0
Pallas, .	301	4	The Moon would fall to the Earth	4	20

OF MERCURY.

Q. What distance is Mercury from the Sun?

A. Thirty-seven millions of miles.

Q. In what time does he move round the Sun?

A. In eighty-seven days twenty-three hours, which is his year.

Q. In what time round his axis?

A. In twenty-four days six hours, which is his day.

Q. What is his diameter?

A. Three thousand two hundred and twenty-four miles.

Q. At what rate does he move in his orbit?

A. At the rate of ninety-five thousand miles an hour.

Q. What *ratio* does the light and heat of Mercury bear to the light and heat of the Earth?

A. The light and heat of Mercury are seven times greater.

Q. What has prevented Astronomers from making any important discoveries respecting this planet?

A. The dazzling splendour of his rays, the shortness of the intervals during which observations can be made on his disc, and his nearness to the vapours of the *horizon* at the time of observation.

Q. How long after sunset can this planet be seen?

A. From his near *vicinity* to the Sun, he cannot be seen later than the twilight, or two hours after sunset.

Q. Who discovered the central motion of Mercury?

A. Schroeter, a German astronomer.

Q. How did he ascertain it?

A. By examining the variations in the daily appearance of Mercury's horns.

Q. Did he succeed in measuring the height of any of the mountains?

A. Yes; and he found some of them to be ten miles and three quarters in height.

Q. What is the appearance of Mercury?

A. It is of a bright colour, with a light tint of blue.

OF VENUS.

Q. Which is the second planet in the system?

A. Venus; whose mean distance from the Sun is sixty-eight millions of miles.

Q. In what time does she revolve round the Sun?

A. In two hundred and twenty-four days seventeen hours.

Q. In what time round her axis?

A. In twenty-four days eight hours.

Q. What is her diameter?

A. Eight thousand three hundred and sixty miles.

Q. What her rate of motion in her orbit?

A. Seventy-six thousand miles an hour.

Q. Whether is Mercury or Venus termed the *morning* and *evening* star?

A. It is Venus.

Q. Can she be both *morning* and *evening* star on the same day?

A. No; she is each, in its turn, for two hundred and ninety days.

Q. When the *evening star*, whether is she on the east, or west side of the Sun?

A. On the east side, for then she sets after the Sun.

Q. On what side when the *morning star*?

A. On the west side, for she then rises before him.

Q. Is Venus ever opposite to the Sun?

A. No; nor is she ever more than ninety-six times the breadth of that luminary from his centre, her greatest *elongation* being about forty-seven degrees.

Q. How long does the Sun continue to shine, without setting, at each of the poles of Venus?

A. For half-a-year in *summer*, and as long without rising in *winter*.

Q. What may be the proportion of light and heat on this planet?

A. It will be double that enjoyed by the Earth.

Q. How may Venus be distinguished from the other planets of the system?

A. From her superior brightness. Her lustre is so great that she is often seen while the Sun is above the horizon.

Q. What are Mercury and Venus denominated from their being within the orbit of the Earth?

A. They are called *inferior* planets, while those without the orbit of the earth are called *superior*.

Q. Do the inferior planets change their phases or aspects like the Moon?

A. Yes; they appear sometimes *horned*, like the new Moon, and sometimes *gibbous*, and the illumined part is always turned to the Sun.

Q. Do the *superior* planets exhibit the same appearances?

A. No; they always appear with nearly a *full face*, with the exception of Mars, which sometimes appears *gibbous*.

Exercises on the Text.

What is that science called which explains the nature and motions of the planets, comets, fixed stars, &c.? What is that part of Astronomy termed which contains an account of the phenomena of the planets, comets, &c.? That which contains the theory of the planetary motions?

Of the Sun.

What is the Sun supposed to be? What does Dr Herschel conceive the bright surface of the Sun to be? What the dark spots on his disc? How many strata of clouds does the Doctor think surround the Sun? Which of these is supposed to serve as a curtain to protect the opaque body of the Sun from the brilliancy and heat of the luminous clouds? Which is the region of that light and heat which are diffused from the centre to the remotest part of the system? How many motions has the Sun? How is it evident that he moves round his axis? In what direction does he move? In what time? What is his diameter? What his circumference? In what direction is the Sun with the whole system moving? What was the size of some of the spots seen by Dr Herschel on the Sun's face? How may the spots on the Sun be imitated?

Of the Planets.

What is a moving star called? What are those that move round the Sun called? What those that move round a primary? How many secondary planets are there? How many has Saturn? How many Jupiter? How many primary planets belong to the system? What are the names of the Asteroids? Where situated? Which is the highest planet in the system? How many are within the orbit of the Earth? What other name has the Georgium Sidus?

Of the Motion of a Planet, and its Cause.

What is that motion called in which bodies move in a straight line? How are bodies drawn from the rectilineal into the curvilineal motion? Why would not a ball, if projected into the open air, continue to move in a straight line, and with the same velocity as was at first impressed upon it? Why do those planets that are near the Sun move quicker in their orbits than those that are more remote from him? Which of them moves quickest in his orbit? Which slowest? In what direction do they move round the Sun? What is meant by the orbit of a planet? What effect has the attractive power of the Sun? What does the projectile force of a planet give it a tendency to? In what sort of orbits do the planets move? Do they move uniformly with the same motion throughout their circuit or orbit? How is the ellipsis in the planet's orbit produced? In what part of a planet's orbit does it move slowest? In what does it move quickest?

Of Mercury and Venus.

How far is Mercury from the Sun? What is the length of his year? What his day? What his diameter? What proportion of light and heat does that planet enjoy? How long after sunset can it be seen? What is the appearance of Mercury? How high did Schroeter find some of the mountains of this planet? When is this planet said to be direct? Where then situate? When retrograde? Where, when stationary? What is the second planet in the system? How far is it from the Sun? What is its diameter? Which of the planets is the morning and evening star? When the evening star, whether is she on the east or west side of the Sun? How long is she each in its turn? What is the proportion of light and heat on Venus? How may she be distinguished from the other planets of the system? What is her greatest elongation from the Sun? At what rate does she move in her orbit? What is the length of her year? Does she change her phases as the Moon does? When these planets are direct, whether are they beyond the Sun or on this side of it? Where, when stationary?

OF THE EARTH.

Q. Which is the planet next in the system?

A. The Earth, whose mean distance from the Sun is ninety-five millions of miles.

Q. In what time does it revolve round the Sun?

A. In nearly three hundred and sixty-five days six hours, which is called its *annual* or *yearly* motion.

Q. What is produced by this revolution?

A. The change of *seasons*.

Q. In what time does it move round its axis?

A. In twenty-four hours, which is called its *diurnal* or *daily* motion.

Q. What is the consequence of this motion?

A. The succession of day and night, and the apparent motion of all the heavenly bodies moving from east to west.

Q. To what cause is the variety in the length of the days and nights ascribed?

A. To the axis of the Earth making an *angle* of nearly twenty-three and a half degrees with the *plane* of its orbit; and of its keeping always the same *oblique* direction, inclining to the same fixed star throughout its annual course.

Q. What would be the consequence if the axis of the Earth were at *right* angles with the plane of its orbit?

A. There would be no variety of days, but the Sun would rise and set at the same hour at all times in the year.

Q. What is the mean diameter of the Earth?

A. Seven thousand nine hundred and twelve miles.

Q. What its mean circumference?

A. Twenty-four thousand eight hundred and fifty-six miles.

Q. What is the rate of motion in its orbit?

A. Sixty-eight thousand miles an hour.

Of the Roundness of the Earth, and of its being nearer the Sun in Winter than in Summer.

Q. How has it been proved that the Earth is round?

A. 1. By an *eclipse* of the Moon; the shadow of the Earth falling upon the Moon during an eclipse is always round. 2. By *navigators* sailing round it, and by the appearance of objects at a distance, as we approach to, or recede from them.

Q. How is this particularly so of ships at sea?

A. When sailing from land, the first thing lost sight of is the *hull*, next the *rigging*, and lastly the *topmast*.

Q. What is the effect when sailing towards the land?

A. The first thing seen is the topmast, next the rigging, and last of all the hull; which phenomena must arise from the *convexity* of the waters of the ocean?

Q. Is the earth exactly *globular* or *spherical?*

A. It is not quite round, but is a little flattened at the Poles, rendering the *polar diameter* shorter than the *equatorial* one by *twenty-five miles*.

Q. What is the difference betwixt the equatorial and polar *circumference?*

A. About *forty miles*.

Q. Whether is the Earth nearer to the Sun in summer or in winter?

A. It is nearer to the Sun by eight and a half degrees in winter than in summer.

Q. How comes it, then, that the Earth is so much warmer in summer than in winter, notwithstanding we are farther from the Sun?

A. In summer, the rays of the Sun fall more *perpendicularly* on the Earth's surface, and therefore come with greater force and in greater numbers on the same place.

Q. What is the difference in winter?

A. In winter, the rays of the Sun have to come through a much colder region, and fall more *obliquely* on the surface of the Earth.

Q. Is there any other cause besides those?

A. Yes; the day being so much longer in summer than in winter, a greater proportion of rays comes on through the day than can go off through the night; which, with the additional heat daily imparted, makes it increase even after the *solstice* or longest day.

Q. Is it from the same cause that we find *July* hotter than *June*, and the day hotter at *two o'clock* in the afternoon than at *mid-day*?

A. Yes; it is from the same cause.

OF THE GREAT CIRCLES.

Q. What is a Great Circle?

A. One that divides the globe into two equal parts.

Q. How many Great Circles are there?

A. Six; the *Equator*, the *Brazen Meridian*, the *Horizon*, the *Ecliptic*, and the two *Colures*.

Q. How does the Equator divide the globe?

A. Into *northern* and *southern* hemispheres.

Q. How does the Meridian?

A. Into *eastern* and *western* hemispheres.

Q. How the Horizon?

A. Into *upper* and *lower* hemispheres, or into sensible and rational Horizons.

Q. What is the *Sensible Horizon*?

A. That line which terminates the view.

Q. What is the *Rational Horizon?*

A. That which applies to the rising and setting of the Sun, Moon, and Stars, and is represented on the artificial globe by the *Wooden Horizon.*

Q. How does the Ecliptic cut the globe?

A. *Obliquely;* the *obliquity* of which is nearly twenty-three and a half degrees.

Q. Why is it called the Ecliptic?

A. Because in it all Eclipses, both *solar* and *lunar,* take place.

Q. What is the *Zodiac?*

A. It is an imaginary broad *circle* or *belt* surrounding the heavens, extending about eight degrees on each side of the Ecliptic, and in which circle the planets constantly revolve; so that no planet is ever seen more than eight degrees either north or south,—that is, above or below the Ecliptic.

Q. What are the names of the twelve signs in the *Zodiac,* and the time of the Sun's entrance into them?

A. I. Aries ♈, or the *Ram,* March 20; II. Taurus ♉, the *Bull,* April 20; III. Gemini ♊, the *Twins,* May 21; IV. Cancer ♋, the *Crab,* June 22; V. Leo ♌, the *Lion,* July 23; VI. Virgo ♍, the *Virgin,* August 23; VII. Libra ♎, the *Balance,* September 23; VIII. Scorpio ♏, the *Scorpion,* October 24; IX. Sagittarius ♐, the *Archer,* November 23; X. Capricornus ♑, the *Goat,* December 22; XI. Aquarius ♒, the *Water-bearer,* January 20; XII. Pisces ♓, the *Fishes*, February 19.

Q. How many of these are called *northern* signs?

A. The first six; and the last six are called *southern* signs.

Q. Which are the *ascending* signs?

A. *Capricornus*, *Aquarius*, *Pisces*, *Aries*, *Taurus*, *Gemini;* because the Sun, in passing through these signs, approaches the North Pole.

Q. Which are the *descending* signs?

A. *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, *Sagittarius;* because the Sun, in passing through these signs, recedes from our Pole.

Q. What are the points of the Ecliptic that intersect or cross the Equator?

A. *Aries* and *Libra.*

Q. What are the names of the *Colures?*

A. They are denominated *Equinoctial* and *Solstitial*, because they cut the globe in these points.

OF THE SMALL CIRCLES.

Q. What are *Small Circles?*

A. Those that do not cut the globe into equal parts; or they are those circles which divide the Earth into zones.

Q. How many are there?

A. *Four;* the *Two Tropics* and the *Two Polar Circles.*

Q. What are the names of the Tropics?

A. *Cancer* and *Capricorn.*

Q. Why are they so called?

A. Because they touch the Ecliptic at the beginning of these signs.

Q. Where are they situated?

A. They are *parallel* to the Equator, and nearly twenty-three and a half degrees distant from it; Cancer being the *northern* Tropic, and Capricorn the *southern*.

Q. How far are the *Polar Circles* from the Poles?

A. The *Arctic* is nearly twenty-three and a half degrees from the *North Pole*, and the *Antarctic* the same distance from the *South Pole*.

OF LATITUDE.

Q. What is *Terrestrial Latitude*?

A. The distance of any place *north* or *south* from the Equator.

Q. Where does it begin and end?

A. It begins at the *Equator*, and ends at the *Poles*.

Q. Where is *Celestial Latitude* reckoned from?

A. It begins at the *Ecliptic*, and ends at the *Arctic* and *Antarctic Circles*.

Q. How much latitude can any place have?

A. Not more than ninety degrees; that being the distance betwixt the Equator and the Poles.

Q. On which of the circles is it reckoned?

A. On the *Brazen Meridian*.

Q. How is the Meridian divided?

A. Into four *quadrants* or *quarters*, each containing ninety degrees; two of which begin to be numbered at the Equator, and increase towards the Poles, to show the north and south latitudes, and the Sun's declination on the *terrestrial globe*, and the declination of the Sun and Stars on the *celestial.*

Q. Where do the other two quadrants begin to be numbered?

A. At the Poles, and increase towards the equator, showing how to *elevate* or *depress* either of the Poles to the latitude of any particular place.

Q. What are those *meridians* called that are drawn through every fifteenth degree of the Equator?

A. *Hour circles;* fifteen degrees on the Equator being equal to an hour.

Q. What are those that stand at every *tenth degree* on the terrestrial globe called?

A. *Circles of terrestrial longitude.*

Q. What is the Earth's circumference?

A. Three hundred and sixty degrees.

Q. What is a degree?

A. The three hundred and sixtieth part of a circle.

OF LONGITUDE.

Q. What is *Longitude?*

A. The distance of any place east or west from the first meridian.

Q. How many degrees of longitude can any place have?

A. No place can have more than one hundred and eighty degrees.

Q. On which of the circles is it reckoned?

A. On the Equator.

Q. At what place does the reckoning commence?

A. At the *first meridian*, which is *arbitrary*, different *Geographers* taking it from different places, as it may best suit their own purposes; but wherever it begins, there is the *first meridian.*

Q. Where do the British take it from?

A. From *the Royal Observatary* at Greenwich, about four miles east from London.

Q. Is longitude reckoned both east and west?

A. Upon the *terrestrial* globe it is; but upon the *celestial* it is reckoned right round from Aries eastward.

OF THE EQUINOXES AND SOLSTICES.

Q. What is the meaning of *Equinox?*

A. It signifies equal day and night.

Q. How many are there?

A. Two; the *Vernal,* which takes place on the 22d of March, and the *Autumnal,* on the 23d of September.

Q. At what time does the Sun *rise* and *set* at the Equinoxes?

A. At six all over the globe; and the *days* and *nights* are of equal length.

Q. Is the globe enlightened from Pole to Pole at the Equinoxes?

A. Yes; because the sun is exactly in the middle of the globe.

Q. What signs does the Sun enter at the Equinoxes?

A. *Aries* at the *Vernal*, and *Libra* at the *Autumnal* Equinox.

Q. What are the *Solstices?*

A. The longest and shortest day.

Q. When is the *Summer Solstice?*

A. On the 22d June.

Q. What sign does the Sun enter then, and what is his declination?

A. He enters *Cancer*, and his declination is nearly twenty-three and a half degrees *north*.

Q. What is declination?

A. The Sun's distance from the Equator.

Q. When is the *Winter Solstice?*

A. On the 22d December, when the Sun enters *Capricorn*, and has then his greatest *southern* declination.

Q. When it is the *longest day* in the *northern* hemisphere, is it the same in the *southern?*

A. No; it is then the *shortest day* to the inhabitants of the *southern* hemisphere.

Q. When have they their longest day?

A. When we have our shortest.

Q. To what cause is it that for some time before and after the solstice we perceive no *sensible* difference in the length of the days?

A. Because at that place the Ecliptic is almost *parallel* to the Equator.

Q. Why is the lengthening and shortening of the day so *perceptible* at the Equinoxes?

A. Because at that place the Ecliptic is the most *oblique*.

Of the Length of the Days at the Equator and the Poles.

Q. What is the length of the day at the Equator?

A. *Twelve hours* from *sunrise* to *sunset.*

Q. Is there any variety of days at the Equator?

A. No; the sun *rises* and *sets* at six o'clock throughout the year.

Q. Do the days increase in length towards the Pole?

A. Yes; they do.

Q. What is the length of the day at the Poles?

A. *Six months.*

Q. Is the opposite Pole, during that time, involved in darkness?

A. No; for during their night the *Moon*, in every *revolution* round the globe, shines for *fourteen* of our days without setting, and as she makes fully *six* revolutions in these six months, they must have six months' *partial moonlight.*

Q. In what *quarter* of the Moon does she begin to shine without setting?

A. At the beginning of the *second*, and she continues to shine till the end of the *third.*

Q. Has the Pole any other light besides that of the Moon?

A. It is *twilight* there, as well as at all other places of the globe, till the Sun is *eighteen degrees* under the horizon.

Q. When does the day begin at the Poles?

A. It begins at the *North Pole* when the Sun crosses the Equator at the *Vernal Equinox*, and continues to shine without setting till the *Autumnal Equinox*, when the day commences at the *South Pole*, where he continues to shine without setting till the *Vernal Equinox*.

OF THE ZONES.

Q. What are Zones?

A. Certain spaces that *encompass* the Earth like a *belt* or *girdle*, and are separated from each other by the *Tropics and Polar Circles*.

Q. How many are there?

A. There are five; viz. the *Torrid*, which includes all that space between the *Tropics*. The two *Temperate*, including the space between the *Tropics* and *Polar Circles*; and the two *Frigid*, including the space lying within the *Polar Circles*.

Q. Is the Sun ever out of the Torrid Zone?

A. No.

Q. How often is he *vertical* to every part of it?

A. *Twice* in the *year*, with the exception of the *Tropics*, where he can only be *once*.

Q. How is the Sun situated with regard to those to whom he is vertical?

A. Directly over their head, or in a direction perpendicular to the horizon.

Q. What is that point of the heavens called which is directly over-head?

A. The *Zenith*; and the opposite point is called the *Nadir*.

EXERCISES.

Of the Earth.

What distance is the Earth from the Sun? How many motions has the Earth? By what is the change of seasons occasioned? By what the change of day and night? Whether is it the annual or diurnal revolution that causes the apparent motion of the heavenly bodies from east to west? What is the consequence of the axis of the Earth's making an angle of twenty-three and a half degrees with the plane of its orbit? What is its diameter? What its rate of motion in its orbit? What is the length of its year? What of its day? What is the figure of the Earth? What proof have you that it is round? What part of a vessel do you first get sight of when sailing towards you? What part do you first lose sight of when sailing from you? Is the Earth quite round? What is the difference in the length of the equatorial and polar diameter? Whether is the polar or equatorial circumference greatest? What is the difference? Is the Earth nearer the Sun in summer or winter? Why is the Earth colder in winter than summer, and hotter in summer than winter? Why is it hotter at two in the afternoon than at midday? What is a circle that cuts the globe into two equal parts called? How many large circles are there? How many small? What is a small circle? What circle divides the globe into northern and southern hemispheres? What into eastern and western? What obliquely? What into upper and lower hemispheres? What is that line which terminates the view called? What is that line which applies to the rising and setting of the Sun, Moon, and Stars called? What is the name of that circle in which all eclipses take place? What is the name of that imaginary broad circle or belt surrounding the heavens, and extending about eight degrees on each side of the Ecliptic? What are the six northern signs of the Ecliptic? What is the obliquity of the ecliptic? What are these two great circles called that cut the globe through the equinoctial and solstitial points? What are the ascending signs? Why are Cancer, Leo, Virgo, Libra, Scorpio, and Sagittarius called descending signs? How many Tropics are there? How far are they from the Equator? Why are they called Cancer and Capricorn? How far are the Polar Circles from the Poles? Which is the Arctic Circle? What is the distance of any place north or south of the Equator called? Where does latitude end? Where does it begin? Upon which of the circles is it reckoned? How many degrees of latitude can any place have? Into how many parts is the meridian divided? Is celestial latitude reckoned from the same point? Where does it end? How many degrees are round the globe? What is a degree? What is longitude? On what is it reckoned? Where does the reckoning commence? How much longitude can any place have? Upon which of the globes is longitude reckoned right round? Where is it reckoned from in the celestial globe? Where from on the terrestrial? How many Equinoxes are there? What their names? When is the vernal? When the autumnal? What circle does the Sun then cross? When is the Earth enlightened from pole to pole? What are the longest and shortest days called? When is the summer solstice? When the winter? At what circles is the Sun then? What is the Sun's declination at the solstices? When has the Sun no declination? What time of the year is it that the days continue for some time nearly of the same length? When is it that the difference in the rising and setting of the Sun is most sensible? Why is it so sensible at that time? What is the length of the day at the Equinoxes? At what hour does the Sun rise and set then? What is the length of the day at the Poles? Has the Pole that has night no light during these six months? How long does the Moon shine at that Pole in every revolution without setting? Have the inhabitants at the Poles any twilight? When does day commence at the North Pole? When is it mid-day there? When does day begin at the South Pole? When is it over? How many Zones are there? What are their names? What is the name of that between the Tropics? That betwixt the Tropic of Cancer and the Arctic Circle? That betwixt the Tropic of Capricorn and the Antarctic Circle? That which lies within the Arctic Circle? Is the Sun ever vertical in the Temperate Zones? What is the Zenith of any place? What is the Nadir?

OF THE MOON.

Q. How many *Satellites* or *Moons* has the Earth?
A. One.

Q. What is the Moon?

A. It is a *solid opaque* body like the Earth.

Q. How many motions has the Moon?

A. *Three;* one round the Earth, one round its own axis, and one round the Sun with the Earth.

Q. In what direction does she move round the Earth, and in what time?

A. She revolves round the Earth, from *west* to *east*, in twenty-nine days twelve hours and forty-four minutes; which is called a *synodical* month. That is the time the Moon takes to revolve from one *conjunction* with the Sun to the next.

Q. What is the length of a *periodical* month?

A. Twenty-seven days seven hours and forty-three minutes; the time the Moon would take to revolve round the Earth, considering the Earth as *stationary.*

Q. How much does the Earth advance in its orbit while the Moon is moving round it?

A. About twenty-nine degrees six minutes and twenty-five seconds.

Q. In what time does the Moon pass over that space?

A. In two days five hours and one minute; which time, added to the *periodical* month, makes twenty-nine days twelve hours and forty-four minutes.

Q. In what time does the Moon move round her axis?

A. In a *synodical* month, or in the same time that she revolves round the Earth; by which means the same side of her is always turned to the Earth.

Q. What is her mean distance from the Earth?

A. Two hundred and forty thousand miles from its centre.

Q. What is her diameter?

A. Two thousand one hundred and eighty miles.

Q. At what rate does she move in her orbit?

A. At a mean rate, thirteen and a half degrees in twenty-four hours.

Q. What are the different *phases* or *aspects* of the Moon termed?

A. When a small part of the enlightened side is seen, it is said to be *crested* or *horned;* when the one-half is visible, it is in *quadrature;* and when a third-part is visible, it is said to be *gibbous.*

Q. In what direction are the horns after the change, and after the full Moon?

A. Immediately after the change, they are turned to the east; and after the full, to the west.

OF ECLIPSES.

Q. By what is an *eclipse* of the *Moon* occasioned?

A. By the Earth's coming between the Sun and the Moon, which can only take place about *full Moon*, when she is said to be in *opposition* to the Sun.

Q. Whether is the Moon without the orbit of the Earth, or within it at the full?

A. She is without.

Q. By what is an eclipse of the Sun occasioned?

A. By the Moon's coming between the Earth and the Sun, which can only happen at *new Moon*, when she is said to be in *conjunction* with the Sun.

Q. Why is there not an eclipse of the Moon every full Moon, and of the Sun every new Moon?

A. Because the Moon's orbit is not *coincident* with the *plane* of the ecliptic, but one-half is elevated five and one-third degrees above, and the other as much depressed below it.

Q. When then can an eclipse take place?

A. When the Sun, Moon, and Earth are all in a *straight line*, called the *line of the nodes*.

Q. On which side of the Moon does an eclipse begin?

A. It always begins on her *eastern* side, and goes off on the *western*, her course being from west to east.

OF THE HARVEST MOON.

Q. What is the difference of time in the *Moon's rising* every night?

A. Generally about *fifty minutes later*.

Q. Why would the Moon, if she moved in the plane of the Equator, rise exactly fifty minutes later every night?

A. Because the Equator makes *equal angles* with the horizon at all times of the day, and at every season of the year; so that *equal portions* of it always rise and set in equal times.

Q. Do the different parts of the ecliptic make the same angles with the horizon when they rise and set?

A. No; those parts or signs that rise with the smallest angles set with the greatest, and those that rise with the greatest set with the smallest.

Q. When does the Moon rise and set with the least difference of time?

A. When she is in those signs that rise and set with the smallest angles.

Q. When does she rise and set with the greatest difference of time?

A. When she is in those signs that rise and set with the greatest angles.

Q. What is the difference of her rising when she is in the 23° of the *sign Leo?*

A. It is so great that thirteen degrees of her orbit, which she describes in a day, rise above the horizon in the space of one hour and seventeen minutes; and, therefore, at that time, the Moon rises one hour seventeen minutes later on the following evening.

Q. What is the effect of the obliquity of her orbit to the horizon when she is in the beginning of *Aries?*

A. It is so sensible that thirteen degrees rise in the short space of seventeen minutes; so that the Moon, at that time, seems to rise for several successive nights nearly at the same hour.

Q. As the Moon is in the beginning of Aries every month, how does she not appear to rise for several nights every month nearly at the same hour?

A. Because she is not full when this takes place, except in the *harvest months*, and consequently the *phenomenon* passes unobserved.

Q. How many *full Moons* are there in the year that *rise* for nearly a *week* at almost the *same hour?*

A. There can be only two; the first of which is called the *Harvest*, and the second the *Hunter's Moon.*

Q. In what signs is the Sun when we have these Moons?

A. In *Virgo* and *Libra.*

Q. In what signs is the Moon then?

A. As the Moon, when full, is always opposite the Sun, she must then be in the signs *Pisces* and *Aries.*

Q. Has the Moon any light besides that immediately derived from the Sun?

A. Our Earth serves her as a Moon, and *waxes* and *wanes* regularly, but appears thirteen times as big, and affords her thirteen times as much light as she does to us.

Q. How does the Earth appear to the Moon when she changes to us?

A. It then appears full to the inhabitants of the Moon, because it is then, with regard to the Moon, exactly in the same situation that the Moon, when full, is to the Earth.

Q. What is that situation?

A. The whole enlightened side of the Earth is turned to the dark side of the Moon, in the same manner that the Moon, when full, shines upon the pole of the Earth, which is then in darkness.

Q. What remarkable appearance is observable of the Moon, in clear weather, a few days after the change?

A. That portion of her disc which is not enlightened by the Sun is *faintly illuminated* by the *solar light* which is *reflected* from the Earth.

Q. How do the horns of the enlightened part appear?

A. They appear to project beyond the *Old Moon*, as they were part of a *sphere*, considerably larger in diameter than the unenlightened part.

Q. How long may this appearance continue?

A. That depends on the state of the weather; if it be clear, it may be seen for four or five days.

OF THE MOTIONS OF THE PLANETS.

Direct, Stationary, and Retrograde.

Q. When is a planet said to be *direct?*

A. When moving from *west* to *east.*

Q. Where is it then situated?

A. Beyond the Sun, or farthest from the Earth.

Q. When is a planet said to be *retrograde?*

A. When it moves from the *east* to the *west;* as it is then said to be going *backward.*

Q. Where is it then situated?

A. Between the Sun and the Earth, or nearest us.

Q. When is it said to be *stationary?*

A. When moving from the direct to the retrograde, or from the retrograde to the direct; because, if then observed in a line with any particular star, it will continue so for a considerable time.

Inferior and Superior Conjunctions of the Planets.

Q. When is a planet said to be in its *inferior conjunction?*

A. When nearest to us,—that is, in a line between us and the Sun.

Q. When is it in its *superior conjunction?*

A. When farthest from us, and the Sun is between us and the planet.

Q. When is a *superior* planet said to be in *conjunction?*

A When the Sun is between the Earth and the planet.

Q. When in *opposition?*

A. When the Earth is between the Sun and the planet,—that is, when the planet is nearest to us.

Q. In which of these positions is it that the planet rises and sets nearly with the Sun?

A. When in *conjunction.*

Q. What takes place when in *opposition?*

A. The planet *rises* nearly when the Sun *sets*, and *sets* when he *rises*.

Q. You say nearly; are they not exactly so?

A. It can only be exactly when the Sun, Earth, and planet are in a right line.

OF MARS.

Q. What is the next planet in the system?

A. Mars; whose distance from the Sun is one hundred and forty-four millions of miles.

Q. In what time does he revolve round the Sun?

A. In one year three hundred and twenty-one days sixteen hours.

Q. In what time round his axis?

A. In one day forty minutes.

Q. What is his diameter?

A. Four thousand one hundred and eighty-nine miles.

Q. What the rate of motion in his orbit?

A. Fifty three thousand miles an hour.

Q. For what is Mars remarkable?

A. For the *redness* of his *colour*, the *brightness* of his *polar regions*, and the great number and variety of spots that mark his surface.

Q. What is supposed to be the cause of the singular redness of this planet?

A. It is thought to be occasioned by the *density* of his *atmosphere;* because when a beam of light passes through any *dense medium*, its colour approaches to red in proportion to the density of the medium and the space through which it has passed.

Q. Do the other heavenly bodies have that appearance?

A. The *Sun*, *Moon*, and *Stars* appear of the same colour when near the *horizon*, and every luminous object seen through a *mist* is of a *ruddy hue*.

Q. Does this planet ever change his appearance like *Mercury* and *Venus?*

A. He sometimes appears *gibbous*, but never *horned*.

OF THE ASTEROIDS, OR FOUR RECENTLY DISCOVERED PLANETS.*

OF VESTA.

Q. What is the *mean* distance of *Vesta* from the Sun?

A. Two hundred and twenty-five millions of miles.

---

* *Of the Origin of the Asteroids.*

"The existence of four planets (Vesta, Ceres, Pallas, and Juno) between the orbits of Mars and Jupiter, revolving round the Sun at nearly the same distances, and differing from all the other planets in their diminutive size, and in the form and position of their orbits, is one of the most singular phenomena in the history of Astronomy. The incompatibility of these phenomena with the regularity of the planetary distances, and with the general harmony of the system, naturally suggests the opinion, that the irregularities in this part of the system were produced by some great convulsion; and that the four planets are fragments of a large celestial body which once existed betwixt Mars and Jupiter. If we suppose the bodies to be independent planets, as they must be, if they did not originally form one, their diminutive size, the great eccentricity and inclination of their orbits, and their numerous intersections, when projected on the plane of the ecliptic, are phenomena absolutely inexplicable on every principle of science, and completely subversive of that harmony and order which, before the discovery of these bodies, pervaded the planetary system: but if we admit the hypothesis, that these planets are the remains of a larger body, which circulated round the Sun in nearly the orbit of the greatest fragment, the system resumes its order, and we discover a regular progression in the distances of the planets, and a general order and harmony in the form and position of their orbits. The elements of the new planets furnish us with several direct arguments, drawn from the eccentricity and inclination of their orbits, and from the position of their perihelion and nodes, and all concurring to show

Q. In what time does she perform her revolution round the Sun?

A. In three years two months and six days.

Q. What is the diameter?

A. Two hundred and thirty-eight miles.

Q. Can this planet be seen by the naked eye?

A. Yes, and its light is more *piercing*, *pure*, and *white* than any of the other three, and is very similar in appearance to the *Georgium Sidus.*

Q. By whom was it discovered?

A. By Dr Olbers, a physician of Bremen in Germany, in 1807.

---

that the four new planets have diverged from one point of space, and have therefore been originally combined in a larger body. When the planet is burst in pieces by some internal force, capable of overcoming the mutual attraction of the fragments, it is obvious that the larger fragment will receive the least impetus from the explosive force, and will therefore circulate in an orbit, deviating less than any other of the fragments from the original path of the large planet; while the lesser fragments, being thrown off with greater velocity, will revolve in orbits more eccentric and more inclined to the ecliptic. Now the eccentricity of Ceres and Vesta is nearly one and a half of their mean distance; the eccentricity of Pallas being a little greater than that of Juno. We should therefore expect from the theory, that Pallas and Juno would be considerably smaller than Ceres and Vesta, and that Ceres should be the larger fragment, and should have an orbit more analogous, in eccentricity and inclination, than that of any of the smaller fragments, to the other planets of the system. In so far as the diameters of the new planets have been measured, the theory is most strikingly confirmed by observation."—*Brewster's Encyclopædia.*

OF CERES.

Q. What is the *mean* distance of *Ceres* from the Sun?

A. Nearly two hundred and sixty millions of miles.

Q. In what time does it revolve round the Sun?

A. In four years seven months and ten days.

Q. What is the diameter of Ceres?

A. Sixteen hundred and twenty-four miles.*

Q. Of what colour is it?

A. It is of a *ruddy colour.*

Q. By whom was this planet discovered?

A. By Piazzi, at Palermo in Sicily, on the 1st January, 1801.

OF PALLAS.

Q. What is the *mean* distance of *Pallas* from the Sun?

A. Two hundred and sixty-six millions of miles.

Q. In what time does it revolve round the Sun?

A. In four years seven months and twenty-one days.

Q. What is the diameter of Pallas?

A. Two thousand and ninety-nine miles.†

---

* This is agreeable to Schroeter's measurement; Dr Herschel makes it but one hundred and thirty-six.

† Dr Herschel makes it eighty miles.

Q. What is the colour of Pallas?

A. It is of a *less ruddy colour* than Ceres.

Q. What is there peculiar in the orbits of Ceres and Pallas?

A. They *mutually intersect* each other.

Q. By whom was Pallas discovered?

A. By Dr Olbers of Bremen, 28th March, 1802.

OF JUNO.

Q. What is the *mean* distance of *Juno* from the Sun?

A. Two hundred and fifty-three millions of miles.

Q. In what time does Juno perform her revolution round the Sun?

A. In four years four months and nine days.

Q. What is its diameter?

A. Fourteen hundred and sixty miles.

Q. For what is Juno particularly distinguished from all the other planets in the system?

A. For the great *eccentricity* of its orbit, the *effect* of which is so *sensible*, that it passes over that half of its orbit which is *nearest* the Sun, in half the time it takes to describe the other half, which is *farther* from him.

Q. From what cause is its greatest distance from the Sun double the least distance?

A. From the same cause,—namely, the great *eccentricity* of its orbit.

Q. By whom was this planet discovered?

A. By Mr Harding of Lilienthal, near Bremen, on the evening of the 1st September, 1804.

EXERCISES.

Of the Moon.

What is the Moon How many motions has she? In what direction does she move round the Earth? In what time? What is a synodical month? What is the length of a periodical month? In what time does the Moon move from one conjunction of the Sun to the next? In what time does she revolve round her axis? What is her distance from the earth? When is she said to be in quadrature? When gibbous? At what rate does she move in her orbit? When is the Sun liable to be eclipsed? When the Moon? When is the Moon said to be in opposition to the Sun? When in conjunction? How much is the orbit of the Moon elevated above the ecliptic? When can an eclipse of the Moon take place? Does the Moon rise at the same hour every night? How much later is it every night? Do equal portions of the Equator always rise and set in equal times? How do those parts of the ecliptic set that rise with the smallest angles? How do those that rise with the greatest? When does she rise and set with the greatest difference of time? What is the difference of her rising when she is in the 23d of the sign Leo? When does the Moon seem to rise for several successive nights at nearly the same hour? Why does not this take place every month? How many full moons are there in the year in which the Moon will seem to rise for nearly a week at almost the same hour? What is the first called? In what signs is the Sun then? In what is the Moon? Have the inhabitants of the Moon any moonlight? What remarkable appearance is observable of the Moon a few days after the change?

Of the Motions of the Planets.

What is the motion of a planet said to be when moving from west to east? What, when nearest the Earth? On what side of the Sun, when said to be stationary? How often, in the course of its circuit round the Sun, is it stationary? How often direct? How often retrograde? What is its position, with regard to the Sun, when direct? What, when retrograde? In what conjunction is a planet said to be when nearest the Earth? What conjunetion is that in which the Sun is between us and the planet? In what is a superior planet said to be when the Sun is between it and the Earth? Whether is it when in opposition or conjunction that a planet rises and sets nearly with the Sun? In which of those positions is it that the planet rises nearly when the Sun sets, and sets when he rises?

Of Mars and the Asteroids.

What is the distance of Mars from the Sun? What is his diameter? In what time does he revolve round the Sun? What is the length of his day? For what is he remarkable? What is the rate of motion in his orbit? What is supposed to be the cause of the red colour of Mars? Does he ever appear gibbous? In what time does Vesta revolve round the Sun? What is her mean distance from the Sun? Can it be seen by the naked eye? By whom was it first discovered? What is the distance of Ceres? What the diameter? What the colour? By whom discovered? What is the mean distance of Pallas from the Sun? By whom discovered? What is there peculiar in the orbits of Ceres and Pallas? In what time does Pallas revolve round the Sun? How far is Juno from the Sun? What is the diameter? For what is this planet particularly distinguished from all the other planets of the system? In what time does it revolve round the Sun? By whom discovered? In what part of the system are the Asteroids situated? What is supposed to be the origin of them?

OF JUPITER.

Q. What is the distance of *Jupiter* from the Sun?

A. Four hundred and ninety millions of miles.

Q. In what time does he revolve round the Sun?

A. In nearly twelve years.

Q. In what time round his axis?

A. He revolves on his axis, which is *perpendicular to his orbit,* in about ten hours, at the amazing rate of twenty-six thousand miles an hour; and by this swift diurnal motion his *equatorial diameter* is six thousand miles greater than his *polar.*

Q. Has this planet any variety in its seasons?

A. As the variety in the seasons of a planet depends on the inclination of its axis to its orbit, and as Jupiter's axis is at *right angles* with the *plane* of his orbit, he can have no difference in his seasons, nor any variation in the length of his days and nights.

Q. What is the diameter of Jupiter?

A. He is the largest of all the planets,—his diameter being eighty-nine thousand one hundred and seventy miles.

Q. What is his *magnitude* compared with that of the Earth?

A. It is more than one thousand times that of the Earth.

Q. What is the rate of motion in his orbit?

A. Twenty-six thousand miles an hour.

Q. How is Jupiter easily distinguished from the other planets of the system?

A. By his peculiar *magnitude* and *brilliancy.* He exceeds all the other planets in brightness, with the exception sometimes of *Venus.*

Q. Are there any belts seen across the disc of this planet?

A. When seen through a good telescope, there are observed several zones or belts extending across his disc or face in lines *parallel* to his equator.

Q. Are these *belts stationary*?

A. They are variable both in number, distance, and position.

OF JUPITER'S SATELLITES.

Q. How many *Satellites* or *Moons* has *Jupiter*?

A. *Four*; which move round him at various distances, and at different periods of time.

Q. In what time do they revolve round him?

A. The nearest in less than two days, and the most distant in little more than sixteen.

Q. Are these Moons, like our own, liable to be eclipsed?

A. Yes; and their eclipses are of considerable importance to the astronomer, who, by means of them, has obtained a method by which the *longitude* of *places* may be determined with greater facility and accuracy.

Q. Have not these eclipses been useful in discovering the motion of light?

A. By these also the motion of *light* has been ascertained to be *progressive*, and not *instantaneous*, as was formerly supposed.

Q. At what rate does light fly?

A. At about twelve millions of miles in a minute; which is more than a million of times greater than of a ball issuing from the loaded cannon.

Q. In what time does a *ray of light* come from the Sun to the Earth?

A. In about *eight minutes and a half*; which is at the rate of about twelve millions of miles in a minute.

Q. By whom were the *Satellites* of *Jupiter* discovered?

A. By Galileo, in 1610.

OF SATURN.

Q. What is the distance of *Saturn* from the Sun?

A. About nine hundred millions of miles.

Q. In what time does he revolve round the Sun?

A. In about thirty of our years.

Q. In what time round its axis?

A. In nearly twelve hours.

Q. What is the diameter of Saturn?

A. About eighty thousand miles.

Q. What the rate of motion in his orbit?

A. Twenty-two thousand miles an hour.

Q. What is the colour of this planet?

A. He shines with *a pale white light*.

Q. What is the proportion of light and heat enjoyed by this planet?

A. About ninety times less than on the earth.

Q. Is the surface of this planet diversified like Jupiter?

A. It is *diversified* with *dark spots and belts*.

Q. What is the figure of Saturn?

A. It is more flattened at the Poles than Jupiter.

Q. What does the flattening of the Poles of the *Earth, Mars, Jupiter, and Saturn,* arise from?

A. From the *centrifugal* force of their *equatorial* parts.

Of the Rings of Saturn.

Q. How is *Saturn distinguished* from all the other planets of the system?

A. By a *large double luminous ring* surrounding his body, like the horizon of an artificial globe.

Q. Are the rings close to the body of the planet?

A. The nearest is *twenty-one thousand miles distant* from it; and its breadth is twenty thousand miles.

Q. What is the breadth of the *outer ring?*

A. It is seven thousand two hundred miles broad.

Q. What is the extent of the vacant space betwixt the two rings?

A. It is two thousand eight hundred and thirty-nine miles.

Q. Has the ring any rotation on its axis?

A. It *revolves* round the planet in ten hours and a half.

OF SATURN'S SATELLITES.

Q. How many *Satellites* or *Moons* has *Saturn?*

A. *Seven;* but they are all so small, and placed at such a distance from the Earth, as not to be seen but by excellent telescopes.

Q. In what time do they revolve round the *primary?*

A. The one nearest to it in twenty-two hours and a half, and the most distant in seventy-nine days seven hours.

Q. Has this last Moon any rotation on its axis?

A. Yes; and, like our Moon, it revolves round its axis in the same time that it revolves round the planet.

Q. Is there any thing remarkable in the position of the orbits of these Satellites?

A. While the orbits of the *six inner ones* all lie in the plane of Saturn's ring, the orbit of the *outermost*, or the most distant from him, deviates considerably from this plane.

Q. Is there any thing further remarkable of this Satellite?

A. It likewise surpasses in brightness, when at its western *elongation*, all the other Satellites, except the *fourth;* at other times it is extremely small, and at its eastern elongation it entirely disappears.

OF THE GEORGIUM SIDUS, OR HERSCHEL.

Q. What is the distance of the *Georgium Sidus?*

A. Eighteen hundred millions of miles, and is the highest in the system.

Q. In what time does he revolve round the Sun?

A. In nearly eighty-four years.

Q. In what time round his axis?

A. In one day sixteen hours and thirty minutes.

Q. What is his diameter ?

A. Thirty-five thousand one hundred and twelve miles.

Q. What the rate of motion in his orbit ?

A. About sixteen thousand miles an hour.

Q. What is the colour of this planet ?

A. It is of a *bluish white*, and appears like a star of the *sixth magnitude*. It can rarely be seen but by means of the *telescope*.

Q. When may he be best seen by the *naked eye* ?

A. In a clear night when the Moon is absent.

Q. When was this planet discovered ?

A. On the 13th March, 1781, by Dr Herschel, who, out of *compliment* to his *royal master*, gave it the name of the Georgium Sidus, or Georgian Star.

Of the Satellites of the Georgium Sidus.

Q. How many *Satellites* has this planet ?

A. *Six* ; all of which were discovered by Dr Herschel.

Q. In what time do they revolve round the planet ?

A. The one nearest the planet performs his revolution round him in nearly six days ; and the most remote, in rather more than a hundred and seven days.

Q. What is there peculiar in these Satellites ?

A. They all move in a *retrograde direction*, and in orbits lying in the same plane of the ecliptic, and almost perpendicular to it.

EXERCISES.

Of Jupiter.

What is the distance of Jupiter from the Sun? What is the length of his year? What his day? Has he any variety in the length of his days? Why has he none? Whether is his polar or equatorial diameter greatest? What is the diameter? What is his diameter compared with the Earth? What the rate of motion in his orbit? Are there any belts or bands across the disc of Jupiter? How is he easily distinguished from the other planets of the system? How many Moons has Jupiter? In what time does the most distant revolve round the Sun? In what time the nearest? Are these Moons liable to be eclipsed? What great advantage has resulted from these eclipses? At what rate does light fly? In what time does a ray of light come from the Sun to the Earth? By whom were the Satellites of Jupiter discovered?

Of Saturn and the Georgium Sidus.

What is the distance of Saturn from the Sun? What is the proportion of light and heat enjoyed by this planet? What is the length of his year? What of his day? What the rate of motion in his orbit? What is his diameter? What is the figure of Saturn? What is the colour? How many rings has he? What distance are they from the planet? What is the breadth of the outer ring? Has the ring any rotation on its axis? What is the extent of the vacant space between the two rings? How many Satellites has Saturn? Can they be seen by the naked eye? In what time does the nearest move round the primary? In what time the most distant? In what respects is this Satellite similar to our own Moon? Is there any thing remarkable in the position of the orbits of these Satellites? Which is the highest planet in the system? How far distant from the Sun is the Georgium Sidus? In what time does he revolve round the Sun? In what time round his axis? What is his colour? What his diameter? What the rate of motion in his orbit? Can it be seen by the naked eye? When was this planet discovered?

By whom? How many Satellites has it? By whom were they discovered? What is peculiar in the motions of these Satellites?

OF THE COMETS.

Q. What are *Comets?*

A. They are bodies that are occasionally seen in the heavens; they have no *visible disc*, and shine only with a *faint light*, accompanied with a *tail* or *train* turned from the Sun.

Q. What is the nature of Comets?

A. When examined with a good telescope, they appear like a *mass of vapours* surrounding a *dark nucleus* of different degrees of *opacity* in different Comets.

Q. What change takes place in a Comet's appearance when it approaches the Sun?

A. As it approaches the Sun, its *pale and cloudy light* becomes more *brilliant,* and when it reaches its *perihelion,* or that part of its orbit which is nearest the Sun, it is often brighter than the planets.

Q. Does the train or tail increase in length as it approaches the Sun?

A. It does.

Q. In what do the orbits of the Comets differ from those of the planets?

A. In their great *eccentricity,*—all of them stretching far beyond the limits of the *Planetary System.*

Q. How many Comets are said to belong to the system?

A. *Upwards of five hundred;* the elements of *ninety-seven* of which have been calculated by different astronomers.

Q. Do they all move in the same direction round the Sun?

A. No; *forty-nine* of those which have been computed move from *west to east*, and *forty-eight* from *east to west.*

Q. What is farther remarkable of Comets?

A. They are of a much greater *density* than the Earth, because some of them are heated in every revolution round the Sun to such a degree as would *vitrify or dissipate* any substance known to us.

Q. What computation did *Sir Isaac Newton* make respecting the Comet that appeared in 1680?

A. He computed the heat of that Comet, when nearest the Sun, to be two thousand times greater than *red-hot iron;* and that being thus heated, it must retain its heat until it comes round again, though its period should be more than *twenty thousand years.**

---

* By consulting the Edinburgh Encyclopædia on the article Comet, there will be found tables containing the elements of *ninety-seven Comets*, which have been observed and calculated by different astronomers, till the year 1808. By comparing together the numbers in the table alluded to, it will appear, 1st, That *twenty-four* have passed between the *Sun and the orbit of Mercury; thirty-three* between the orbits of *Mercury and Venus; twenty-one* between the orbits of *Venus and the Earth; fifteen* between the orbits of the

OF THE FIXED STARS.

Q. What are those heavenly bodies called that lie beyond our system?

A. They are called ***Fixed Stars***; because, with some few exceptions, they never appear to change their places with regard to each other, as the planets do. They are likewise supposed to be Suns to other systems that revolve round them.

Q. Can any *analogy* be traced between them and our Sun?

A. Yes; it is found, from observation, that many of the Stars move round their axis, as the Sun does; there have also been discovered spots on the surface of many of them.

Q. Are they all equally distant from the Earth, and placed in one *concave surface*, as the face of the heavens, to appearance, represents them?

A. No; they are placed at immense distances from one another, through *unlimited space*; so that there may be as great a distance between any two neighbouring Stars as between the Sun and those that are nearest to him.

Earth and Mars; *three* between the orbits of *Mars and Ceres*; and *one* between the orbits of *Ceres and Jupiter*. 2d, That *thirty-two* Comets have been seen between *April and September*; *sixty-five* between *September and April*. 3d, That the greatest part of the Comets have their *perihelia* nearest to their *ascending nodes*; that the orbits of the Comets are not confined to any particular region of the heavens, but seem to have every possible direction.

Q. When examined through a good telescope, do they appear to have any sensible disc?

A. No; and their size rather diminishes by increasing the magnifying power of the instruments.

Q. How much nearer is the Earth to some of the Fixed Stars in one part of its orbit than in another?

A. *One hundred* and *ninety millions of miles.*

Q. Do the *apparent magnitudes*, *situations*, and *distances* from one another, while the Earth is in these different positions, still remain the same?

A. Yes.

Q. What is the distance of the nearest Star computed to be?

A. *Sirius*, or the *Dog-star*, which, from its *brilliancy*, is supposed to be the nearest, is computed to be *twenty billions* of miles.

Q. In what time would a ray of light pass through that space?

A. Not in less than *three years.*

Q. In what time would a ball, shot from the Earth, reach the nearest Star?

A. In about *seven hundred thousand years.*

Q. Into how many different classes or orders are the Stars distributed?

A. Into *six*; those that appear *largest* are called Stars of the *First Magnitude*; the next to them in *lustre* are called Stars of the *Second Magnitude*; and so on to the *sixth*, which are the smallest seen by the naked eye.

Q. What is the greatest number seen by the naked eye at any time?

A. About *three thousand.*

Q. How are the Fixed Stars distinguished from the Planets?

A. In the first place, the *Stars* have a *twinkling appearance*, while the *Planets* shine with a *steady uniform light.* In the second place, the Stars, though they rise and set, are *stationary* with regard to one another, while the Planets are always in motion.

Q. Whether are the Planets or Stars first seen in the evening?

A. The Planets are *earliest* seen in the *evening*, and *latest* in the *morning*.

Q. Are the Stars uniformly scattered over the firmament?

A. No; they are found *crowded* together in some places, while in other parts of the heavens there are *blank spaces* where no Stars are to be seen.

Q. Are the Stars as numerous above the horizon *by day as by night?*

A. They are as numerous, but they cannot be discerned, being lost in the *effulgence* of the Sun's rays.

Of the Nebulae, or Small Clusters of Stars.

Q. Why are these *roups* called Nebulae?

A. Because they appear as minute, whitish spots, much like small *light clouds*.

Q. What number of these Nebulae is supposed to be in the heavens?

A. There were formerly known to be *one hundred and three;* but Dr Herschel has given a catalogue of *two thousand*, which he has discovered; and his opinion is that the starry heaven is replete with these Nebulae.

Q. What does the Doctor think further respecting these Nebulae?

A. That each of them is a distinct and separate system, independent of the rest.

Of the Galaxy, or Milky-way.

Q. What is the *Galaxy, or Milky-way?*

A. It is a white and *luminous zone* which nearly encirles the heavens, and which appears the nearest of all the Nebulae.

Q. In what direction does it encircle the globe?

A. If you begin at Auriga, it passes on toward the south through the head of Monoceros, leaving Orion and Canis Major to the westward; then it passes through the rigging of Argo Navis, Robur Carolinum, and Crux; thence it passes along by Centaurus and Lepus, and takes in the tail of Scorpio, the foot of Serpentarius, and part of the bow and arrow of Sagittarius; it then passes on between Antinous and Serpentarius, including Scutum Sobieski, where it divides, one part taking in Acquila, Vulpecula, and one wing of Cygnus; the other, beginning at Serpentarius, includes a small part of Cerberus, part of the tail and wing of Lyra, and the neck, body, and tail of Cygnus, where they join again and become one, and pass between Cepheus and Lacerta, taking in Cassiopeia, where it inclines towards the *equinoctial*, and takes in Perseus, and so meets again at Auriga, finishing that great *circumference*.

Q. Did Dr Herschel examine a part of the Galaxy ?

A. He examined a portion of it, about fifteen degrees long and two broad, and found that space to contain no fewer than *fifty thousand Stars*, large enough to be distinctly counted, and he suspected twice as many more ; but from want of light in his telescope he saw only at times.

OF THE CONSTELLATIONS.

Q. What is a *Constellation* ?

A. A *group* of Stars which the ancients fancied resembled some figures or animals with which they were familiar, as the *Waggon*, the *Bear*, &c.

Q. What are those Stars called that lie in the spaces between each Constellation ?

A. They are called *unformed Stars*.

Q. In what Constellation is the *North Pole Star* ?

A. In the tail of the *Little Bear*.

Q. What are the figures of those Constellations in that division of the heavens called the *Zodiac* ?

A. They are mostly figures of animals ; as, *Aries*, the *Ram*, *Taurus*, the *Bull*, &c.

The XII. Constellations in the Zodiac.

	Constellations.	No of Stars.	Names of the principal Stars, and their Magnitudes.
1.	Aries, *The Ram*, . .	6	Arietes, 2.
2.	Taurus, *The Bull*, . .	141	Aldebaran, 1. The Pleiades. The. Hyades.
3.	Gemini, *The Twins*, . .	85	Castor and Pollux, 1. 2.
4.	Cancer, *The Crab*, . .	83	Acubene, 4.
5.	Leo, *The Lion*, . .	95	Regulus or Lion's Heart. 1. Deneb, 2.
6.	Virgo, *The Virgin*, .	110	Spica Virginis, 1. Vindemiatrix, 2.
7.	Libra, *The Balance*, .	51	Zuben el Chamah, Zuben el Gemunbi, 3, 2.
8.	Scorpio, *The Scorpion*, .	44	Antares, 1.
9.	Sagittarius, *The Archer*, .	60	
10.	Capricornus, *The Goat*, .	51	Deneb Algedi, 4.
11.	Aquarius, *The Water-bearer*,	108	Scheat, 3.
12.	Pisces, *The Fishes*, . .	113	

The XXXIV. Northern Constellations.

	Constellations.	No of Stars.	Names of the principal Stars, and their Magnitudes.
1.	Mons Mænalus, *The Mountain Mænalus*, .	11	
2.	Serpens, *The Serpent*, .	64	
3.	Serpentarius, *The Serpent-bearer*, ...	74	Ras Alhagus, 2.
4.	Taurus Poniatowski, *Bull of Poniatowski*, .	7	
5.	Scutum Sobieski, *Sobieski's Shield*, ...	8	
6.	Aquila, *The Eagle*, Antinous.	71	Altair, 1.
7.	Equulus, *The Little Horse*,	10	
8.	Leo Minor, *The Little Lion*,	53	
9.	Coma Berenices, *Berenice's Hair*, . . .	43	
10.	Asterion and Chara, or Canes Venatici, *The Greyhounds*,	25	
11.	Boötes, *The Drover*, .	54	Arcturus, 1. Mirach, 3.
12.	Corona Borealis, *The Northern Crown*, . .	21	Alphecca, 2.
13.	Hercules, ... Cerberus, *The three-headed Dog*, . . .	113	Ras Algethi, 3. in the head of Hercules.
14.	Lyra, *The Harp*, .	22	Lyra, *or* Vega, 1.

Constellations.	No of Stars.	Names of the principal Stars, and their Magnitudes.
15. Vulpecula and Anser, *The Fox and Goose*,	37	
16. Sagitta, *The Arrow*,	18	
17. Delphinus, *The Dolphin*,	18	
18. Pegasus, *The Flying Horse*,	89	Markab, 2. Scheat, 2.
19. Andromeda,	66	Mirach, 2. Almaach, 2.
20. Triangulum, *The Triangle*,	11	
21. Triangulum Minus, *The Little Triangle*,	5	
22. Musca Borealis, *The Northern Fly*,*	6	
23. Ursa Minor, *The Little Bear*,	24	Alruccabah *or* Pole Star, 2.
24. Ursa Major, *The Great Bear*,	87	Dubhe *or* Upper Pointer, 1. Alioth, 2. Benetnach *or* Lower Pointer, 2.
25. Cor Caroli, *Charles's Heart*,	3	
26. Draco, *The Dragon*,	80	Etanim, 2.
27. Cygnus, *The Swan*,	81	Arided, 1.
28. Lacerta, *The Lizard*,	16	
29. Cepheus,	35	Alderamin, 3.
30. Cassiopeia,	55	Schedir, 3.
31. Perseus, Caput Medusa, *Head of Medusa*,	59	Algol, 2.
32. Camelopardalus *The Camelopard*,	58	
33. Auriga, *The Charioteer or Waggoner*,	66	Capella, 1.
34. Lynx, *The Lynx*,	44	

---

* In the latitude of Edinburgh, all Stars, of which the declinations are above 34° 3′ N., are never seen to set; and Stars, of which the declinations are above 34° 3′ S., are never visible.

The XLVII. Southern Constellations.

Constellations.	No of Stars.	Names of the principal Stars, and their Magnitudes.
1. Cetus, *The Whale*,	97	Menkar, 2. Mira, 3.
2. Eridanus, *The river Po*,	84	Achernar, 1.
3. Orion,	78	Betelgeux, 1. Rigel, 1. Bellatrix, 2.
4. Monoceros, *The Unicorn*,	31	
5. Canis Minor, *The Little Dog*,	14	Procyon, 1.
6. Hydra,	60	Cor Hydræ, 2.
7. Sextans, *The Sextant*,	41	
8. Microscopium, *The Microscope*,	10	
9. Piscis Notius or Australis, *The Southern Fish*,	24	Fomalhaut, 1.

Constellations.	No of Stars.	Names of the principal Stars, and their Magnitudes.
10. Officina Sculptoria, *The Sculptor's Shop*, . .	12	
11. Fornax Chemica, *The Chemical Furnace*, . . .	14	
12. Brandenburgium Sceptrum, *The Sceptre of Brandenburg*,	3	
13. Lepus, *The Hare*, . .	19	
14. Columba Noachi, *Noah's Dove*,	10	
15. Canis Major, *The Great Dog*,	31	Sirius or Dog-star, 1.
16. Pyxis Nautica, *The Mariner's Compass*, . . .	4	
17. Machina Pneumatica, *The Air-Pump*, ...	3	
18. Crater, *The Cup or Goblet*,	31	Alkes, 3.
19. Corvus, *The Crow*, . .	9	Algorab, 3.
20. Centaurus, *The Centaur*, .	35	
21. Lupus, *The Wolf*, . .	24	
22. Norma, or Quadra Euclidis, *Euclid's Square*, .	12	
23. Circinus, *The Compasses*, .	4	
24. Triangulum Australe, *The Southern Triangle*, .	5	
25. Crux, *The Cross*, . .	6	
26. Musca Australis or Apis, *The Southern Fly or Bee*, .	4	
27. Chamæleon, *The Cameleon*,	10	
28. Ara, *The Altar*, . .	9	
29. Telescopium, *The Telescope*,	9	
30. Corona Australis, *The Southern Crown*, . .	12	
31. Indus, *The Indian*, . .	12	
32. Grus, *The Crane*, .	13	
33. Pavo, *The Peacock*, . .	14	
34. Apus, or Avis Indica, *The Bird of Paradise*, . .	11	
35. Octans Hadleianus, *Hadley's Octant*, . . .	43	
36. Phœnix, ...	13	
37. Horologium, *The Clock*, .	12	
38. Reticulus Rhomboidalis, *The Rhomboidal Net*, .	10	
39. Hydrus, *The Water-Snake*,	10	
40. Touchan, *The American Goose*,	9	
41. Mons Mensæ, *The Table Mountain*, . .	30	
42. Praxiteles, or Cela Sculptoria, *The Graver's or Engraver's Tools*, . . .	16	
43. Equuleus Pictorius, *The Painter's Easel*, ...	8	
44. Dorado, or Xiphias, *The Sword-Fish*, . . .	7	
45. Argo Navis, *The Ship Argo*,	64	Canopus, 1.
46. Piscis Volans, *The Flying-Fish*,	8	
47. Robur Caroli, *Charles's Oak*,	12	

A Table of the *Right Ascension* and *Declination* of some of the most eminent *Fixed Stars*. Those marked with an *asterisk* in the following Table, are those from which the distance of the Moon is calculated in the *Nautical Almanack* for the purpose of ascertaining longitude.

Names and Constellations.	R. A.		Declin.		
	°	'	°	'	
Aldebaran, *in Taurus*,*	66	00	16	5	N.
Algenib, *in Pegasus*,*	00	38	13	25	N.
Alioth, *in Ursa Major*,	191	12	57	5	N.
Alcair, or Altair, *in Aquila*,*	295	9	8	20	N.
Albiero, *in Cygnus*,	290	35	27	32	N.
Aridef, *in ditto*,	308	35	44	33	N.
Achernar, *in Eridanus*,	22	29	58	18	S.
Alfetu, *in Corona*,	231	29	27	26	N.
Arcturus, *in Boötes*,	211	34	20	18	N.
Arietis, *in Aries*,	28	52	22	28	N.
Asingue, *in Lyra*,	277	28	38	36	N.
Bellatrix, *in Orion*,	78	30	6	9	N.
Belelguise, *in ditto*,	85	59	7	21	N.
Beninaeg, *in Ursa Major*,	204	50	50	21	N.
Canobus, *or Canopus, in Argo Navis*,	94	56	52	35	S.
Castor, *in Gemini*,	110	19	32	20	N.
Castor's *Brother Pollux, ditto*,*	113	8	28	31	N.
Capella, *in Auriga*,	75	20	45	46	N.
Cor Hydræ, *Hydra's Heart*,	139	20	7	46	S.
Cor Scorpionis, *Scorpio's Heart*,*	244	10	25	57	S.
Cor Leonis, *called Regulus*,*	149	19	12	59	N.
Denib, *in Leo Major*,	174	37	15	44	N.
Erif, *in Pegasus*,	323	29	8	56	N.
Fomalhaut, *in Southern Fish*,*	341	32	30	43	S.
Gauby, *in Libra, South Scale*,	219	52	15	10	S.
Marhal, or Markab, *in Pegasus*,	343	36	14	5	N.
Menkar, *in Cetus*,	42	51	3	16	N.
Procyon, *in Canicula*,	112	6	5	45	N.
Pis Centauri,	216	29	59	58	S.
Regel, *or Rigel, in Orion's Foot*,	76	8	8	27	S.
1. Star *in the Girdle of Orion*,	80	21	0	28	S.
2. —— *ditto*,	81	25	1	21	S.
3. —— *ditto*,	82	34	2	4	S.
Scheat, *in Pegasus*,	343	25	26	57	N.
Sheder, *in Cassiopeia*,	7	12	55	24	N.
Sirius, *in Canis Major*,	99	0	16	26	S.
Spica, *in Virgo*,*	198	34	10	4	S.
Lower Pointer, *in Ursa Major*,	162	18	57	30	N.
Upper Pointer, *in ditto, called Dubhe*,	162	42	62	52	N.
Vindemiatrix, *in Virgo*,	192	57	12	5	N.

Of the Comets, Fixed Stars, and Constellations.

What is the nature of Comets? How many are said to belong to the System? Do they all move in the same direction round the Sun? What change takes place in the appearance of a Comet as it approaches the Sun? Is the orbit of a Comet the same as that of a Planet? In what do they differ? What is farther remarkable of Comets? What are the Fixed Stars supposed to be? Why are they called Fixed Stars? What is the distance of the nearest Star? Which is the nearest? How much nearer is the Earth to some of the Fixed Stars in one part of its orbit than in another? In what time would a ball shot from the Earth reach the nearest Star? In what time would a ray of light come from Sirius? Are the Stars all at the same distance from the Earth? Into how many classes are they divided? What is the greatest number seen by the naked eye at any time? Are they uniformly scattered over the firmament? How are they distinguished from the Planets? Are they as numerous by day as by night? What are those called Nebulae? What number of them is supposed to be in the heavens? What is the Galaxy, or Milky-way? What was the portion of it examined by Dr Herschel? What number of Stars did he find in it? What is a Constellation? In what one is the North Pole Star? How many are in the Zodiac? What sort of figures are they? How many northern ones are there? How many southern?

OF THE EBBING AND FLOWING OF THE OCEAN.

Q. By whom was the true cause of the *Tides* first assigned?

A. By Kepler, who says that the waters of the Ocean *gravitate* toward the *Moon*, and cause the *Tides.*

Q. What was Sir Isaac Newton's opinion?

A. He demonstrated that the *Tides* are a consequence of the law of *universal gravitation*, the phenomena being exactly such as ought to result from the attraction of the Sun and Moon exerted on the waters of the ocean.

Q. In what proportion does the power of *gravity diminish?*

A. It diminishes as the square of the distances increases,—that is, a body at twice the distance attracts another with only a *fourth* part of the force, at four times the distance, with a *sixteenth* part of the force, &c.

Q. How does this principle apply to the Tides?

A. The waters on the side of the Earth *next the Moon* are more attracted by her than the waters on the *opposite side* of the Earth; and, therefore, the distance between the waters on the Earth's centre and those under and opposite to the Moon will be increased.

Q. What is the effect produced by the *conjunction* or change of the Moon, when the *Sun and Moon* act in a *direct line* with each other?

A. The attractive force of the Sun and Moon being united, diminishes the *gravity* of the water under the Moon, and is productive of *Spring or High Tides.*

Q. How is the gravity of the waters on the opposite side of the Earth diminished?

A. By means of the *Centrifugal Force.*

Q. What is the centrifugal force?

A. It is that force by which all bodies moving in circles have a tendency to fly off from their centres.

Q. Does this force throw off as much water on the side of the Earth which is turned from the Moon, as is raised by her attraction on the side next her?

A. It does.

Q. What is the effect produced on the Tides by the *full Moon*, or when she is in *opposition?*

A. She then raises the Tides under and opposite to her, or, which is the same thing, lets the water on the opposite side remain.

Q. What is the effect produced by the Sun acting in the same line with the Moon?

A. The Sun raises the Tides under and opposite to him in the same way as the Moon does, though in a smaller proportion.

Q. What then is their *combined effect?*

A. The effect is the same as at the change, and, in both cases, occasions what we call the *Spring Tides*.

Q. What is the interval or period between one Spring Tide and another?

A. *Fifteen days* nearly; the time of high water at any place being at the same hour after that lapse of time.

Q. What takes place when the Moon is in *quadrature* with the Sun?

A. The action of the one luminary then *diminishes* the effect produced by the other, and causes what is called the *Neap Tides*.

Q. Is the influence of the Sun as great as that of the Moon on the waters of the ocean?

A. The distance of the Sun is so great that he produces little more than a *fourth part of the effect*.

Q. When do the greatest Tides happen?

A. *In winter* the *Spring Tides* are greater than in *summer*, and the *Neap Tides* smaller; the Sun being nearer the Earth in winter than in summer.

Q. How often does the Tide *ebb and flow* in twenty-four hours?

A. *Twice.*

Q. What is the difference of time betwixt the *flux and reflux*?

A. About *six hours twelve minutes* and a *half*.

Q. What is the distance of time between the *two floods*?

A. Twelve hours twenty-five minutes; making *two Tides of flood and two of ebb* in twenty-four hours and fifty minutes, which period is called a *lunar day*.

Q. How are the two floods and the two ebbs thus produced?

A. By the *rotation* of the Earth on its axis; each part of its surface, to which the Moon is vertical, being presented to the action of the Moon.

Q. Are the Tides very *sensible* in the *ocean*?

A. In open seas the Tides rise but to a very *small height* compared with what they do in confined places, or in wide-mouthed rivers opening in the direction of the stream of the Tide.

Q. Why do the waters rise higher in channels growing gradually narrower?

A. Because the waters are accumulated by the opposition of the contracting banks.

Q. Are the Tides much retarded in their progress by shoals, and by striking against capes, headlands, &c.?

A. Yes; under such circumstances their motion becomes variable, and their height depends on many circumstances.

Q. In what direction do the different currents of the Tides flow?

A. From the *north and south*, in the direction of the *Sun and Moon*,—that is, towards the Equator.

Q. How does that from the Northern Hemisphere flow?

A. From the North Cape, along the coast of Norway, towards the Naze, and so proceeds along the *east coast* of Britain.

Q. Does it, in its passage, supply all the harbours on the coast with the Tide, one after another?

A. Yes; and those on the coast of Scotland have the Tide first, as being farthest north.

Q. When is it *high water* at Aberdeen on the days of *full and change*?

A. At forty-five minutes past twelve.

Q. When at Tynemouth-bar on the same day?

A. Not till three o'clock.

Q. When at the Spurn?

A. At a little after five; but not at Hull till six; that time being required for its passage up the river Humber.

Q. When is it high water at Yarmouth Roads on that day?

A. It makes high water there a little after eight, but not in the pier of Yarmouth till nine, and it requires nearly an hour more to reach the town.

Q. When does it make flood-tide at Harwich?

A. At half-past ten.

Q. When at the Nore?

A. At twelve.

Q. When at Gravesend?

A. At half-past one, and at London at a quarter before three o'clock.

Q. What does this show?

A. That the same Tide that produces high water at Tynemouth-bar at three o'clock in the morning, does not produce high water at London till a quarter before three in the afternoon.

Q. While the Tide or high water is flowing south along the east coast of Britain, does it not also flow southward along the *west coast* of Scotland and Ireland?

A. Yes; and a branch of it falls into St George's Channel, the flood running up north-east.

Q. How does it appear that the Tide flows in that direction?

A. From its being *high water* at Waterford above *three hours* before it is high water at Dublin, or in that neighbourhood of the coast.

Q. What is the state of the Tide at Dublin when it is high water at the Isle of Man?

A. When it is *high water* at the Isle of Man, it is three quarters of an hour *ebb* at Dublin.

Q. Does not a branch of the Tide from the coast of Ireland *flow eastward* through the *English Channel*, by the coast of England and France.

A. Yes; and when it reaches the Goodwin, on the *east coast of Kent*, it meets the Tide which flows to the *southward*, along the *eastern coast* of Britain.

Q. What is the consequence of the *meeting* of these *two Tides?*

A. It contributes very much towards sending a *powerful Tide* up the *River Thames* to London.

Q. Is not the course of the Tide *east*, or *east north-east*, up the Channel inconsistent with the *theory* which supposes it to move from *east to west?*

A. In the ocean, where the Tides meet with no obstruction, they regularly follow the influence of the *Sun or Moon* in moving from *east to west*.

Q. What direction do they take in rivers, channels, and narrow seas?

A. They flow in every direction, as the waters in the neighbourhood may be higher or lower; it being well known that water, if not counteracted by some superior power, always endeavours to come to a level.

Q. Are there any Tides in lakes?

A. No; because the Moon attracts every part of a lake alike, so that no part of it can be more raised than another.

Q. Have the inland seas any Tides?

A. The inlets by which the Mediterranean and Baltic Seas communicate with the ocean, are so narrow, that they cannot, in so short a time, receive or discharge enough to raise or sink their surfaces sensibly.

Of the Tides.

By whom was the true cause of the Tides first assigned? What did he say was the cause? What was Sir Isaac Newton's opinion? In what proportion does the power of gravity diminish? How does a body at twice the distance attract another? How, at four times the distance? Whether are the waters of the ocean next the Moon more or less attracted by her than those on the opposite side of the Earth? Does the Sun, as well as the Moon, attract the waters of the ocean? Which has the most powerful effect? What is the effect produced on the ocean by the change of the Moon, or when she is in conjunction with the Sun? What is the effect produced on the Tides by the full Moon, or when she is in opposition? What is the combined effect of the Sun and Moon when she is in opposition? By what are the Neap Tides occasioned? What is the interval or period between one Spring Tide and another? When do the greatest Tides happen? When the smallest Neap Tides? What is the cause of the Spring Tides being greater, and the Neap Tides smaller in winter than in summer? How often does the Tide ebb and flow in twenty-four hours? Are the Tides very sensible in the ocean? How are the two floods and ebbs produced? Why do the waters rise higher in channels growing gradually narrower? In what direction do the different currents of the Tides flow? How does that from the North Cape flow? When is it high water at Aberdeen on the days of full and change? When is it at Hull? When at Harwich? When at Gravesend? When at London? Does the Tide flow up along the west coast of Britain as well as the east? Does the Tide flow north-east from the south of Ireland? Whether is it high water at Dublin or Waterford first? Does the Tide flow east the English Channel and through the Straits of Dover? What is the effect of the two Tides meeting opposite the east coast of Kent? In what direction do the Tides flow in rivers, channels, &c.? Have the inland seas any Tides?

OF TERRESTRIAL GRAVITY.

Q. What is *Terrestrial Gravity?*

A. That force by which bodies are continually urged to the Earth.

Q. What is the effect produced by the power of gravity on a body at rest, supported by another, or suspended by a string, or in any other way kept from falling?

A. The *force of gravity* causes it to stretch the string by which it is suspended, or to press upon its supports.

Q. What is the effect when a body at rest is left unsupported?

A. It falls to the Earth, in the direction of a line perpendicular to its surface.

Q. Are the spaces through which a body falls always proportional to the *squares* of the times of *descent?*

A. Yes; for, at the end of the intervals of time 1, 2, 3, 4, &c. seconds, the spaces the body has descended are as the numbers 2, 4, 9, 16, &c.

Q. Do all bodies, whether great or small, descend through the same space in the same time?

A. Yes; except so far as they are hindered by the *resistance* of the air.

Q. Through what space does a body fall, by the force of gravity, in one *second* of time?

A. It falls through *sixteen feet* and *one inch*.

Q. At the end of that time, through what space would it fall in another second, if the force of gravity were to cease to act upon it, and allow it to continue its motion uniformly.

A. Agreeably to the laws of *accelerated* motion, it would fall through double the space, or *thirty-two* feet *two* inches.

Q. What is another effect of gravitation?

A. When a body is *projected* in any direction *oblique* to the horizon, it *deflects* the body from the line in which the projection was made, and bends its path into a curve.

Q. In what does this phenomenon afford a most instructive lesson?

A. In the *theory* of the planetary motions; as upon this principle the planets revolve round the Sun.

Q. What would be the consequence if the attractive power of the Sun were not counteracted by the projectile force of the planet?

A. The Sun, being so large a body, would naturally draw all the planets into him. *See the Article on the Motion of the Planets, and its Cause, p.* 9.

Q. What is meant by the verb to *gravitate?*

A. Nothing is meant but the fact that all bodies, or the planets, either actually approach or manifest a tendency to approach the body to which they are said to gravitate.

Q. How is the quantity of matter in a body estimated?

A. By its weight.

Q. Do all bodies of equal magnitude contain equal quantities of matter?

A. No; for a *ball of cork*, being more porous than a *ball of lead*, though of the same size, must be much lighter, and consequently contain a less quantity of matter.

Q. How is gravity demonstrated to be as the quantity of matter in bodies?

A. As every particle of matter has its proper *gravity*, the effect of the whole must be in proportion to the number of the attracting particles,—that is, as the quantity in the whole body.

Q. Is it not evident, then, that the power or force of gravity is always proportional to the quantity of matter in bodies, whatever their bulk or figures may be?

A. Yes.

Q. What is the *centre of gravity*?

A. It is that point of a body in which the whole force of its gravity or weight is united; therefore, whatever supports that point bears the weight of the whole body.

Q. What is the *line of direction*?

A. It is an imaginary line, drawn from the *centre of gravity* of any body, toward the centre of the Earth, and in this line all heavy bodies descend, if not obstructed.

OF THE ATMOSPHERE.

Q. What is the *Atmosphere*?

A. It is that invisible *elastic fluid* which surrounds the Earth, and encloses it on all sides to a considerable height.

Q. Why is it called a fluid?

A. Because it has all the properties by which a fluid is distinguished.

Q. Mention some of these properties.

A. It yields to the least pressure, its parts are easily moved among one another, it presses according to its *perpendicular* height, and its pressure is every where equal.

Q. In what does the Air differ from all other fluids?

A. It can be compressed or made to occupy a much smaller space than it naturally possesses, which no other fluid can.

Q. Can it be *congealed* or fixed as other fluids may?

A. No.

Q. Is it of a different *density* in every part upward from the Earth's surface?

A. Yes; and it decreases in its weight the higher it rises, and it must consequently decrease in density.

Q. Is *Air* of an elastic nature?

A. Yes; and its *elasticity* is equal to its weight.

Q. How do you prove that Air is a body?

A. If a glass-jar or any other vessel be plunged with its mouth downward into water, very little will get into the jar, because the Air, of which it is full, excludes the water.

Q. As Air is a body, it must have gravity or weight; how is this demonstrated?

A. A bottle that holds a quart, being emptied of Air by means of the air-pump, and weighed, is found to be sixteen *grains* lighter than when the Air is let into it again; which shows that a quart of Air weighs sixteen grains.

Q. What is the difference between the weight of *Air* and that of *Water?*

A. Water is eight hundred and twenty times as heavy as Air is near the surface of the Earth.

Q. By whom was the weight of the Atmosphere ascertained?

A. By *Galileo.*

Q. What application did *Torricilli* make of the gravity of the Atmosphere?

A. It was by this that he explained the rise of *water* in pumps, and of *mercury* in the *barometrical* tubes.

Q. How high does water rise by means of the pump?

A. It will not rise higher than thirty-two or thirty-three feet.

Q. What is it that causes the water in the pump to follow the *piston* when the Air above it is lifted up?

A. It is the pressure of the *Atmosphere* on the surface of the water in the well.

Q. How is this proved?

A. By taking a tube of about forty feet in length, shut at one end, and filling it with water, and then plunging it into a vessel of water, the *fluid* will then descend in the tube till the weight of the column exactly equals the pressure of the Atmosphere.

Q. Why will the weight of the column exactly equal the weight of the Atmosphere?

A. Because the Air is now excluded from the upper part of the tube, and the weight of the column of fluid is the only force which is left to balance the weight of the atmospherical column.

Q. In making this experiment, how high will the water be found to stand in the tube?

A. At from thirty-four to thirty-five feet above the general level of the surrounding fluid?

Q. What would be the consequence if the tube were open at the top?

A. The pressure would be equal on both, and the water in the tube would fall to the level of the surrounding fluid.

Q. What does this demonstrate?

A. That the weight of a *column* of Air reaching to the top of the Atmosphere is equal to the weight of a column of water of the same base with the *altitude* of thirty-four feet.

Q. What is it on a square foot?

A. About twenty-one thousand five hundred and sixty-four and a half pounds.

Q. What is it on a square inch?

A. Fifteen pounds on every square inch.

Q. How high will *mercury* rise in the *tube* of the *barometer*?

A. To the height of about *thirty inches*. Hence it follows that the whole Atmosphere exerts the same pressure on the surface of the Earth as if the surface of the globe were covered with water to the depth of about *thirty-four feet*; or with *quicksilver* or *mercury* to the depth of about *thirty inches*.

Q. Do not the changes which take place in the Atmosphere render its pressure liable to very considerable variations?

A. The column of quicksilver, which has been shown as the measure of that pressure, varies from *twenty-eight* to *thirty-one inches*.

Q. If we suppose that a *man* of an *ordinary size* exposes a surface of nearly fifteen feet to the pressure of the Atmosphere, what must be the weight he sustains?

A. When the Air is of a *mean gravity*, he *must sustain* a pressure of fourteen and a half *tons*.

Q. How is he capable of supporting such a weight?

A. It is by the pressure being equal on every part, and being *counterbalanced* by the spring of the Air within, which is diffused through the whole body, and *reacts* with an equal force against the outward pressure.

Q. What is the height of the Atmosphere?

A. It appears from the duration of *twilight*, that at the height of *forty-four and a half miles*, it is sufficiently *dense* to intercept the light of the sun, and to reflect it to the earth: though it is seldom dense enough at *two miles* to suspend or bear up the clouds.

Q. Does it grow gradually *rarer* the higher it ascends?

A. Yes; the lowest stratum supporting the weight of almost the whole Atmosphere will be more dense than the rest, and the superior strata will gradually become more *rare* in proportion to the weight which they sustain; the Air in the higher regions, therefore, will be extremely rare or thin in consequence of its elasticity, which is not checked by any *superincumbent* pressure.

Q. Of what is the Atmosphere composed?

A. It was long considered as a simple elementary body; but it is now known to consist of at least four distinct substances; namely, *oxygen*, *nitrogen*, *carbonic acid gases*, and *aqueous vapour*.

Q. Which are considered its essential constituents?

A. The first two constitute almost the whole of it; the other two exist only in minute quantities.

Q. Is the composition of the Atmosphere always the same?

A. Yes; it is universally admitted that it is the same in all places and in all seasons.

Q. Which of the constituents of the Air is the most important?

A. *Oxygen*, which is indeed not only one of the most important, but one of the most remarkable substances in nature.

Q. What are some of its properties?

A. It possesses the mechanical properties of Air, *combustibles* burn in it with great brilliancy, and animals can breathe it much longer than the same quantity of *common Air*.

Q. What are the properties of *nitrogen*?

A. It is chiefly recognised by its *negative* qualities, it possesses the mechanical properties of air, it does not support combustion, and it is death to any animal that breathes it.

Q. What are the properties of *carbonic acid gas*?

A. It is of so very *deleterious* a nature, that were it to accumulate to any extent, it would render Air incapable of supporting life.

Q. Will a candle burn in this gas?

A. A candle will not burn in Air contaminated with one-ninth of carbonic acid gas.

Q. Is there much of this gas in the Air?

A. The quantity is very small.

Q. How is it demonstrable that *aqueous* vapour forms a part of the Atmosphere?

A. By the *rain* and *dew* that are continually falling, and by the great quantity of moisture which *sulphuric acid*, *potash*, and other bodies *absorb* when exposed to the Atmosphere.

Q. What good purposes does the Atmosphere serve?

A. It serves to suspend the clouds, and furnish us with wind and rain, and answer the common purposes of breathing.

Q. Does it serve any other cause?

A. It is also the cause of the morning and evening *twilight*, and of all the glory and brightness of the *firmament*.

Q. What do experiments on the *air-pump* prove with regard to the Atmosphere?

A. They prove that without the Air or Atmosphere no animal could exist; without its aid all vegetation would cease, and sound could not be produced without it.

Q. What appearance would the sky present to us if there were no Atmosphere?

A. Without it, no part of the heavens would appear light but that in which the Sun was placed; and if a person could turn his back to the Sun, all that part of the heavens before him would be dark as night.

Q. What are the effects produced on the Atmosphere by *heat* and *cold*?

A. Heat *expands* or *increases* its bulk, while cold *contracts* or *diminishes* it.

EXERCISES.

Terrestrial Gravity and the Atmosphere.

By what name is that force called by which bodies are continually urged to the Earth? What is the effect when a body at rest is left unsupported? Do all bodies, whether great or small, descend through the same space in the same time? Are the spaces through which a body falls always proportional to the squares of the times of descent? Through what space does a body fall by the force of gravity in one second of time? What would be the consequence if the attractive power of the Sun were not

counteracted by the projectile force of the planets? How is the quantity of matter in a body estimated? How is gravity demonstrated to be as the quantity of matter in bodies Do all bodies of equal magnitudes contain equal quantities of matter? What is that point of a body called in which the whole force of its gravity is united? Why is the Atmosphere called a fluid? What is the Atmosphere? In what does it differ from all other fluids? Is the Air, at the surface of the Earth, of a different density from that which is more distant? How do you prove that Air is a body? By whom was the weight of the Air ascertained? What application did Torricelli make of the weight of the Air? What is the weight of a quart of Air? What is it that causes the water to ascend in the pump and follow the piston, when the Air above it is lifted up? How high will water rise by means of the pump? To what is the weight of a column of Air, reaching to the top of the Atmosphere, equal? What is the weight of the Atmosphere on a square inch? How high will mercury rise in the tube of the barometer? If the surface of the globe were covered with water, what depth would be equivalent to the weight of the whole Atmosphere? If of quicksilver, what depth would be equal to the weight of the Atmosphere? What is the height of the Atmosphere? What pressure does an ordinary-sized man support? Of what is the Atmosphere composed? Is the composition the same in all places and in all seasons? What is the principal constituent in the composition of Air? What are some of the properties of oxygen? What are the properties of nitrogen? What do experiments on the air-pump prove with regard to the Atmosphere? If there were no Atmosphere, what appearance would the sky present to us? What effects do heat and cold produce on the Atmosphere?

OF THE WINDS.

Q. What is the cause of the *Winds?*

A. When a column of air is heated above the temperature of an adjacent column, it has a tendency to rise in consequence of its diminished *specific gra-*

vity; while the colder air flows in to supply its place.

Q. Explain this by some familiar circumstances.

A. It is from this cause that the Air rushes with such force into a *glass-house*, or toward any place where a great fire is kept.

Q. Is it also from the same cause that smoke is carried up the chimney?

A. Yes; the Air about the fire being so much *rarefied* by the heat, that the colder air, from the adjacent parts of the room, rushes in to restore the *equilibrium*,—thus keeping up a constant current of Air through the chimney.

Of the Trade Winds.

Q. What are the *Trade Winds*?

A. They are Winds that blow constantly from *east* to *west* on the *Torrid* Zone.

Q. How are they produced?

A. When the Sun shines perpendicularly on any part of the Earth, the Air naturally becomes very much heated, and causes it to ascend to the higher regions of the Atmosphere; while the adjacent colder Air rushes in to supply its place, causing a steady breeze almost the whole year from east to west, extending to about *thirty degrees* on each side of the Equator.

Q. Does not their direction decline a little from due east?

A. It does toward the parallel to which the Sun is *vertical* at different seasons of the year, being a little *northerly* when the Sun's declination is north, and *southerly* when his declination is south.

Q. In what state is the Trade Wind in the *Great Pacific Ocean?*

A. It blows with a gentle and uniform breeze during the whole year; so much so that Spanish vessels trading between the western coasts of *South America* and the *Manilla Islands*, are said to traverse this *vast ocean* in ten weeks without having once occasion to alter a sail.

Q. What is the prevailing Wind on the north and south of the Trade Wind?

A. Beyond the *Tropics* the prevailing Wind on each side is from the *west;* a current of Air having that direction seems to be necessary to restore the equilibrium of the Atmosphere, which is so incessantly disturbed by the action of the Trade Winds.

Of the Sea and Land Breezes.

Q. What are the Sea and Land Breezes?

A. Winds blowing alternately from the land and sea are observed to prevail in most places which have a *maritime* or *insular* situation. These Winds are most distinctly felt between the Tropics.

Q. Do they change their direction with great regularity every twenty-four hours?

A. Yes; blowing from the *sea* to the *land* during the *day*, and from the *land* to the *sea* during the *night.*

Q. What is the cause of these changes?

A. It is supposed to be owing to the unequal effect of the Sun upon the Atmosphere over the land and the ocean.

Q. What is the effect of the air over the land being so much warmer during the day than that which is over the ocean?

A. The denser Air over the ocean overcomes, by its greater weight or pressure, the resistance of the Air over the land, and thus occasions a flux of the Atmosphere from the sea towards the land.

Q. What takes place during the night?

A. During night the state of things is reversed, and a current of Air is determined by the denser Air rushing from the land to the sea.

Of the Monsoons.

Q. What are the *Monsoons*?

A. *Periodical* Winds, which, in the *Indian Seas*, blow half a year one way, and the other half another way.

Q. To what cause have they been ascribed?

A. To the superior temperature acquired by the southern part of the African and Asiatic continents during the time the Sun is *vertical* to it, in consequence of which an *aerial current* takes place from the sea towards the land.

Q. Describe what part of the ocean is thus affected by it.

A. In that portion of the *Indian Ocean* lying between Sumatra and the African coast, and from three degrees of south latitude to the Asiatic coast, including the Arabian Sea and the Gulf of Bengal.

Q. In what direction do the Monsoons blow from *September* to *April?*

A. *North-east*, or nearly in the general direction of the Trade Wind.

Q. How, from *April* to *September?*

A. They change to the *south-west*, and move in with the land to the *west-south-west.*

Q. What is remarked during the former period?

A. That the Wind is more steady, and the weather less liable to changes.

Of the Velocity of the Wind, &c.

Q. What is the *velocity* of the Wind?

A. It varies in every possible degree from *one* to *fifty miles* per *hour;* but the *medium* is from *twelve* to *fifteen* miles per hour.

Q. What are *cardinal* Winds?

A. Those that blow from east, west, north, and south.

Q. What are *collateral* Winds?

A. Those that blow between the cardinal points.

OF REFRACTION.

Q. What is *Refraction?*

A. It is in general the *deviation* of a moving body in its direct course, occasioned by the different *density* of the *medium* it moves in, or it is a change of direction, occasioned by a body's falling *obliquely* out of one *medium* into another of a different *density*.

Q. What is the great law of *Refraction* which holds in all bodies and in all mediums?

A. It is this, that a body passing obliquely out of one medium into another, where it meets with less resistance, is refracted or turned towards the perpendicular.

Q. When is it refracted or turned from the perpendicular?

A. In passing out of one medium into another where the resistance is greater.

Q. Are the rays of light falling out of Air into water refracted *towards* the perpendicular?

A. Yes.

Q. Is a *ball* when thrown into the water refracted *from* the perpendicular?

A. Yes.

Q. What is the reason of this difference?

A. The cause is, that *water*, which resists the motion of *light* less than *Air* does, resists that of the *ball* more; or, to speak more correctly, because *water* by its greater attraction *accelerates* the motion of the rays of light more than Air does.

Q. What is the effect produced on the heavenly bodies by this refractive power of the Atmosphere?

A. All the heavenly bodies appear higher than they really are, and hence they often appear above the horizon when they are actually below it.*

---

* At Paris, on the 19th July, 1780, the Moon was seen eclipsed above the horizon, while the Sun itself was distinctly visible, which

Q. Illustrate this by experiment.

A. Put, in an empty vessel, a *piece of money*, and retire from it till the *edge* of the vessel just intercepts the money from the sight, and hold the head steady while another person pours water gently into the basin; the money will appear wholly to view as if lifted up.

Q. What is the cause of this?

A. The *ray*, which was *straight* while the basin was empty, is now bent at the surface of the water, and turned out of its *rectilineal* course. Now suppose the *edge* of the basin to be the *horizon*, the *water* the *Atmosphere*, and the *piece* of *money* the *Sun* or *Moon*, it is quite obvious that it will be seen above the horizon when really below it.

Q. Give another example.

A. Let a *staff* be immersed *perpendicularly* in a vessel of water, it will have no Refraction, or will not appear *bent*; but by inclining the staff towards the side of the vessel, it will appear *bent* at the *surface* of the water, and the more it is inclined the greater will be the Refraction.

Q. To what cause is the *oval* appearance of the *Sun* and *Moon*, when near the horizon, to be ascribed?

A. To the same cause; for, as the *lower limb* of

---

was evidently owing to Refraction; for at full Moon the Sun and Moon are diametrically opposite, and therefore could not both be seen at the same time.

the *Sun* or *Moon* is nearer the horizon than the *upper one*, it is raised more by the Refraction of the Atmosphere; and consequently the *vertical diameter* of the *luminary* is contracted, while the *horizontal diameter* remains the same.

Q. How long does the Refraction of the Atmosphere bring the Sun in view before he rises, and keep him in view after he sets?

A. Above six minutes every day, at a mean rate.

OF THE TWILIGHT.

Q. What is the *Twilight*?

A. It is a *medium* between light and darkness, and happens every morning before *sunrise*, and every evening after *sunset*.

Q. What is the cause of it?

A. While the Earth's Atmosphere refracts the rays of light, it has also a *reflective* power.

Q. What is the effect of this?

A. By it the light of the Sun is returned to the Earth in an enfeebled state after his direct rays have been intercepted by the horizon.

Q. What is this phenomenon called?

A. The Twilight or *crepuscular* light.

Q. How far is the Sun under the horizon when it begins in the morning and ends in the evening?

A. About eighteen degrees.

Q. Is the length of the Twilight always the same?

A. It continues longer when the Ecliptic or the Sun's apparent path in the heavens [illegible]ue, to the horizon.

Q. When is it oblique to the horizon?

A. In *winter and summer*, when his declination is great.

Q. Why does it continue longer then?

A. Because his *perpendicular* distance from the horizon increases slowly.

Q. When is the Twilight of short duration?

A. When the Ecliptic cuts the horizon more *perpendicularly*.

Q. When does this take place?

A. In the *autumn* and *spring*, when the Sun is near the Equator, as his distance then from the horizon increases with great rapidity.

Q. What is the length of the Twilight at the Equinoxes, or when the Sun is on the Equator?

A. Two hours in the morning, and as many in the evening.

Q. Does Twilight ever continue from *sunsetting* to *sunrising*?

A. Yes; when the Sun's declination, added to 18°, exceeds the *colatitude* of any place, the parallel of declination will not cut the parallel of 18° below the horizon; and therefore there will be no real night in that latitude during that time. Thus there is no real night at *Edinburgh* from *5th May* to *9th August*,—that is for about *fourteen* weeks.

Q. Does Twilight continue longer in *high* or in *low* latitudes?

A. In *high* latitudes; because it requires a longer time to *raise* or *depress* the 18°, which form the limit of Twilight, in a high latitude than in a lower, where the Sun rises more perpendicularly to the horizon.

OF THE PRECESSION OF THE EQUINOXES.

Q. What is the *precession* of the Equinoxes?

A. It is a very slow motion which the *equinoctial* points are known to have from *east* to *west*, directly contrary to the order of the signs themselves, which is from *west* to *east*.

Q. Why is the *retrograde* motion of the *equinoctial* points called *precession*?

A. Because it advances the time of every Equinox a little sooner than it would have otherwise happened.

Q. At what rate do they move?

A. At the rate of one degree in seventy-two years, or of fifty seconds in one year.

Q. What is the effect of this *retrograde* motion of the equinoctial points, and by that means of the whole Ecliptic?

A. By this motion they have *receded* or gone back from their *constellations*, or, which is the same thing, the Constellations have *preceded* or gone before their signs, in which they were at first; for originally they were together.

Q. In what time will the equinoctial points make a full revolution?

A. In about twenty-five thousand nine hundred and twenty years from the beginning of the *precession*, as appears by multiplying three hundred and sixty degrees, which are the number of degrees in the Ecliptic, by seventy-two years.

Q. What is the reason that the equinoctial points and all the rest of the signs stand not in their own but in different constellations?

A. It is from the recession of these points; as the *asterism* or constellation Aries is not now in its own sign, but in the sign *Taurus*, Taurus in the sign *Gemini*, and Gemini in *Cancer*, &c., quite round the Ecliptic, as is plainly exhibited on the Celestial Globe.

Q. When will the signs and their constellations be together again?

A. At the end of the year twenty-five thousand nine hundred and twenty from the beginning of the said recession, which is called the *Platonic* year.

EXERCISES.

Of the Winds.

What is the cause of the Winds? What is it that causes the Air to rush with such force into any place where a great fire is kept up? From what cause does the smoke ascend through the chimney? In what direction do the Winds blow on the Torrid Zone? What are the Trade Winds? How are they produced? Does not their direction decline a little from due west? What is the prevailing Wind on the north and south of the Trade Wind, or to the north and south of the Tropics? What account do those who traverse the Pacific Ocean give of the state of the Winds on the Torrid Zone, or where the Trade Winds prevail? What are those Winds called which blow alternately from the land and sea, and are observed to prevail in most places which have a maritime or insular situation? What is supposed to be the cause of these changes? Where is the breeze from during night? Do these changes take place regularly every twenty-four hours? What are those Winds called Monsoons?

In what direction do they blow from September to April? To what cause have they been ascribed? Over what part of the ocean do they extend? How or in what direction do they blow from April to September? What is generally the velocity of the Wind? Does it vary much? What are those called that blow from east, west, south, and north?

Of Refraction and the Twilight.

What is Refraction? What is the great law of Refraction which obtains in all mediums? What takes place when a ray of light passes out of one medium into another, where the resistance is greater? Whether does water or Air resist the motion of light most? What is it that makes all the heavenly bodies appear higher than they really are, and often to appear above the horizon when they are actually below it? Mention a remarkable occurrence of this refractive power which took place at Paris. Illustrate this by that well-known experiment of the empty vessel and the piece of money in the bottom of it. What does the edge of the basin represent? What the piece of money? What is the cause of this singular appearance? Will a staff, if immersed perpendicularly into water, appear bent? What would give it that appearance at the surface of the water? To what cause is the oval appearance of the Sun and Moon, when near the horizon, to be ascribed? What is the Twilight? What is the effect of the reflective power of the Atmosphere? How far is the Sun under the horizon in the morning when twilight begins? When is the twilight greatest? What is the length of it at the Equinoxes? At what hour does it begin in the morning on the 22d March? When is it over in the evening of the 23d September? Why is the twilight longer in summer and winter than in the other seasons of the year? Does twilight ever continue from sunsetting to sunrising? When is it so? How long in the latitude of Edinburgh will there be no real night?

OF THE EQUATION OF TIME.

Q. What is meant by the *Equation* of Time?

A. It is the difference of time between a well-regulated *clock* and a true *sun-dial.*

Q. Explain the natural consequence of the Earth's motion on its axis being perfectly *equable*, or always at the same rate.

A. It thereby causes an apparent equable motion of the *starry* heaven round the same axis produced to the poles of the heaven.

Q. Do equal portions of the *celestial* Equator pass over the *meridian* in equal parts of time?

A. Yes; because the axis of the world is perpendicular to the plane of the Equator.

Q. What would be the consequence if the Sun kept his *annual* course in the celestial Equator?

A. He would always revolve from the meridian to the meridian again in exactly twenty-four hours, as shown by a well-regulated clock.

Q. Does the Sun, when moving in the Ecliptic, revolve from meridian to meridian in twenty-four hours?

A. No; it is sometimes a little sooner, and at other times a little later.

Q. Why is it so?

A. Because equal portions of the Ecliptic, in consequence of its obliquity, pass over the meridian in unequal parts of time, and this difference is the same in all latitudes.

Q. How do you show this by the globe?

A. Make *chalk-marks* all around the Equator and Ecliptic at equal distances from one another, suppose ten degrees, beginning at Aries or Libra, where the Ecliptic intersects the Equator. Then turn the globe round on its axis, and you will see that all the marks in the *first* quadrant of the Ecliptic, or from the beginning of Aries to the beginning of Cancer, come sooner to the brazen meridian than their corresponding marks do on the Equator.

Q. What do those on the second?

A. Those on the *second* quadrant, or from the beginning of Cancer to the beginning of Libra, come later.

Q. What do those on the third?

A. Those on the *third* quadrant, from Libra to Capricorn, come sooner.

Q. What do these on the fourth?

A. Those on the *fourth*, from Capricorn to Aries, later.

Q. Do those at the beginning of each quadrant come to the meridian at the same time with those corresponding marks on the Equator?

A. Yes.

Q. What do these results show?

A. That while the Sun is in the *first* and *third* quadrants of the Ecliptic, he comes *sooner* to the meridian every day than he would do if he moved in the Equator; and consequently he is *faster* than a well-regulated clock, which always keeps equable or equatorial time.

Q. What does it show while he is in the *second* and *fourth* quadrants?

A. That he comes *later* to the meridian every day than he would if he kept in the Equator, and is therefore *slower* than the clock.

Q. What happens at the beginning of each quadrant?

A. The sun and clock are then equal?*

Q. Is there any other cause for the difference of time besides that you have stated?

A. Yes; the inequality of the Sun's apparent motion, which is slowest in summer when the Sun is farthest from the Earth, and swiftest in winter when he is nearest to it.

Q. What may be the difference?

A. In winter it sometimes exceeds a degree in twenty-four hours, while in summer it is generally less than a degree.

Q. What will be the effect when his motion is slowest?

A. Any particular meridian will move sooner than when his motion is quickest; for it will overtake him in less time when he advances a less space, than when he moves through a larger.

OF LEAP YEAR.

Q. How has the year been most generally divided?

A. Into twelve months of thirty days.

Q. Of how many days did the ancient *Hebrew* month consist?

---

* Time, as measured by the *sun-dial*, is represented by the marks on the Ecliptic, and is called *apparent time*; that measured by a *good clock* by those on the Equator, and is called *mean time*.

A. Of thirty each, with the exception of the last, which contained thirty-five.

Q. Of how many days did the *Athenian* month consist?

A. Agreeably to the regulation of Solon, it consisted of thirty and twenty-nine alternately, making the year three hundred and fifty-four days, and a little more than one-third.

Q. How did *Meton* reconcile the difference between the *solar* and *lunar* year?

A. By adding several intercalary months during a *cycle* or revolution of nineteen years.

Q. What was the length of the *Roman* months in the time of Romulus?

A. They were only ten of thirty and thirty-one days.

Q. Who supplied this deficiency?

A. Numa Pompilius, by adding two more months, which made a year of three hundred and fifty-five days.

Q. What was the length of the *Egyptian* year?

A. Three hundred and sixty-five days.

Q. Who was the first that attained to any accuracy on the subject?

A. Julius Cæsar, finding the year established by Numa ten days shorter than the *solar*, supplied the difference, and fixed the length of the year to be three hundred and sixty-five days six hours.

Q. How did he allow for the six odd hours?

A. He added an intercalary day every fourth year to the month of February, reckoning the twenty-fourth of that month *twice*.

Q. Of what number of days is that year?

A. It must of course consist of three hundred and sixty-six days, and is called *Leap Year;* and from Julius Cæsar it was called the *Julian* year.

Q. By what other name is Leap Year known?

A. *Bissextile*, and the day added is called the intercalary day.

Q. How do you ascertain at any time what year is *Leap Year*?

A. By dividing the date of the year by four, if there is no remainder, it is Leap Year; thus 1828 was Leap Year, because that number divided by four leaves no remainder.

Q. What was 1827?

A. The third year after Leap Year, because that number divided by four leaves a remainder of three, showing it to be the third year.

Q. What is 1829?

A. It will be the first year after Leap Year, because when divided by four the remainder is one.

Q. How long did the *Julian* year continue in use?

A. Till the year 1582, when Pope Gregory reformed the *calendar* by cutting off ten days between the fourth and fifteenth of October in that year, and calling the 5th day of that month the 15th.

Q. Was the alteration of the style gradually adopted throughout the greater part of Europe?

A. Yes; and the year was afterwards called the Gregorian year, or *New Style*.

Q. When was this method of reckoning, according to the *New Style*, admitted into our calendars?

A. Not till the year 1752, when the error amounted to nearly eleven days, which were taken from the month of September, by calling the third of that month the fourteenth.

Q. When was the beginning of the year changed from the 25th March to the 1st January?

A. In 1752, by the same act of Parliament which admitted the New Style into our calendar.

Of the Precession of the Equinoxes.

What is that slow motion called which the equinoctial points are known to have from east to west? What is the order of the signs? At what rate do these points move? In what time will they make a full revolution? How does this appear? Were the constellations and their signs in the Ecliptic originally together? Why are they not so now? When will the signs and their constellations be together again.

Of the Equation of Time.

What do you call the difference of time betwixt a well-regulated clock and a true sun-dial? Why do equal portions of the celestial Equator pass over the meridian in equal parts of time? Does the Sun, when moving in the Ecliptic, revolve from meridian to meridian in twenty-four hours? What would be the consequence if the Sun kept his annual course in the celestial Equator. Why is the Sun, in revolving from meridian to meridian in twenty-four hours, sometimes a little earlier, and at other times a little later? How do you show this by the globe? Whether do the marks on the first quadrant of the Ecliptic come sooner or later to the brazen meridian than their corresponding marks on the Equator? What do

those in the quadrant, from Cancer to Libra? Do those at the beginning of each quadrant come to the meridian at the same time? In what quadrants of the Ecliptic does the Sun come sooner to the meridian than he would if he moved in the Equator? Whether is he then faster or slower than a well-regulated clock? Whether does he come sooner or later when in the second and fourth quadrants? When are the Sun and clock equal? By what is time, measured on the sun-dial, represented? What is time, measured by a good clock, represented by? What time is that which is called apparent? What is that time which is measured by a good clock called? Is there any other cause for the difference of time besides that just mentioned? Whether is it in summer or winter that the Sun's apparent motion is greatest? Why is the motion greatest in winter? Upon what principle does it move quicker in winter? What is the difference of his motion in winter? What is the difference in summer?

On Leap Year.

Of how many days did the ancient Hebrew month consist? How did Meton reconcile the difference between the solar and the lunar year? How did Numa Pompilius supply the deficiency in the months that were in use during the time of Romulus? What was the length of the Egyptian year? What alteration did Julius Cæsar make in the length of the year? How many days are in the Julian year? By what other name is it known? What change did Pope Gregory make in the year? When was the method of reckoning, according to the New Style, admitted into our calendars?

PROBLEMS

TO BE

SOLVED ON THE TERRESTRIAL GLOBE.

I.—*To find the latitude and longitude of any place.*

Rule.—Find the place, and bring it to the brass meridian;* the degree above the place is the latitude; look on the Equator, and the degree under the edge of the meridian is the longitude required.

Examples.—What are the latitude and longitude of St Petersburgh? Ans. Lat. 59° 56′ N., long. 30° 25′ E. What are the latitude and longitude of Madrid, Rome, Constantinople, Moscow, Quebec, Lima, Madras?

II.—*To find all those places that have the same latitude as any given place.*

Rule.—Bring the given place to the meridian, and observe its latitude, turn the globe round, and all those places that come under the same latitude are the places required.

III.—*To find all those places that have the same longitude as any given place.*

Rule.—Bring the given place to the brass meridian, and all those places that lie under the edge of the meridian from Pole to Pole are the places required.

---

* It is always the graduated edge of the brazen meridian or the quadrant that is meant.

IV.—*To find a place by the latitude and longitude given.*

RULE.—Bring the longitude to the brass meridian, and under the given latitude will be found the place.

Ex.—What place is that of which the latitude is 59° 56′ N., and the longitude 30° 25′ E ? Ans. St Petersburgh. What place has latitude 40° 25′ N., long. 3° 20′ W. ? What place has latitude 46° 55′ N., long. 69° 48′ W.

V.—*To find the difference of latitude or longitude between any two places.*

RULE.—Find the latitude of both places, and if both north or both south of the Equator, subtract the lesser from the greater; the difference is the answer required. If one is north and the other south, add them, and their sum will be the difference required.

Ex.—What is the difference of latitude betwixt Constantinople and St Petersburgh.

St Petersburgh,	59° 56′ N.
Constantinople,	41° 1′ N.
Difference,	18° 55′

What is the difference of latitude betwixt Cape of Good Hope and Grand Cairo ?

Cape of Good Hope,	34° 29′ S.
Cairo,	30° 3′ N.
Difference,	64° 32′

The difference of longitude is found in the same way, but instead of using the meridian you use the Equator. Thus, betwixt Mecca in Africa and Canton in China.

Canton,	113° 7′ E.
Mecca,	40° 55′ E.
Difference,	72° 22′

What is the difference betwixt Madrid and Cairo ?

Madrid,	3° 20′ W.
Cairo,	31° 23′ E.
Difference,	34° 43′

VI.—*The hour of the day being given in one place, to find what hour it is at that time in any other place.*

RULE.—Bring the place where the hour is given to the meridian, and set the index of the hour-circle to the given hour. Turn the globe till the other place comes under the meridian, and the index will show the hour required. The time will be earlier if the latter place lie east of the former, but later if it lie on the west. Thus when it is two o'clock afternoon at London, it is 22 minutes past four afternoon at Jerusalem, and 52 minutes past eight in the morning at Kingston in Jamaica.

Ex.—When it is two in the morning at London, what is it at Jerusalem, and at Kingston, Jamaica? Ans. 4 hours 22 minutes afternoon at Jerusalem, and 8 hours 52 minutes morning at Jamaica.

Ex.—When it is noon at Edinburgh, what is it at Lima, Madras, Rio Janeiro, and Mecca?

VII.—*To find the distance between any two places.*

Rule.—Lay the quadrant of altitude over the two places, and mark the number of degrees between them; multiply the degrees by 69½ for English miles, and 60 for geographical miles; or it may be done by taking the distance between the two places by a pair of compasses, and applying it to the Equator, which will show the distance in degrees, and multiply as formerly.

Ex.—What is the distance between London and Constantinople in degrees and English miles? Ans. 22° nearly, and 1529 miles. What is the distance between Paris and Mecca, between Rome and Bombay, between Lisbon and Quebec?

VIII.—*To rectify the globe for the latitude of any place.*

Rule.—Elevate the north or south poles as many degrees above the horizon as are equal to the latitude of the place.

Ex.—What is the latitude of Edinburgh, London, Rome, Stockholm? It is respectively 55° 55′—51° 35′—41° 54′—59° 20′.

IX.—*To find the Sun's place in the Ecliptic for any day.*

Rule.—Find the day of the month on the wooden horizon, and opposite to it in the adjoining circle are the sign and degree in which the Sun is for the given day; find the same sign and degree in the circle of the Ecliptic on the globe, and that is the Sun's place.

Ex.—What is the Sun's place on the 22d March, the 16th June, the 22d December, the 12th August? It is respectively, 1st, Aries, —25th, Gemini,—1st, Capricornus,—20th, Leo.

X.—*To find at what hour the Sun rises and sets, and the length of the day and night at any place.*

Rule.—Rectify the globe for the latitude of the place; find the Sun's place in the Ecliptic for the day, and bring it to the meridian; set the index to 12, and turn the Sun's place to the eastern edge of the horizon, the index will show the hour of rising; bring it to the western edge of the horizon, and the index will show the time of setting. The time of sunrising doubled gives the length of the night; and the time of sunsetting doubled gives the length of the day. Thus, if the Sun rise at 8, the night is 16 hours, and if he set at 4, the day is 8 hours.

Ex.—At what time does the Sun rise and set at Madrid on the 26th May?

Ans. 4 h. 30 m. time of rising;	7 h. 30 m. time of setting.
2	2
9 h. 0 m. length of the night;	15 h. 0 m. length of the day.

What is the length of the day and night at Paris, Edinburgh, London, Rome, on the 17th June? 22° August, and 23° September.

Note.—The complement of rising and setting is exactly 24 hours.

XI.—*The day of the month being given, to find the Sun's declination, and to what places the Sun will be vertical on that day.*

Rule.—Bring the Sun's place in the Ecliptic for the given day to the meridian, and mark what degree is over it, for that is the declination, and is northern or southern as the place may be on the north or south side of the Equator; turn the globe, and all the places that pass under that degree will have the Sun vertical on that day.

Ex.—What is the Sun's declination, and to what places will he be vertical on the 10th of May? Ans. 18° N. declination, and he is vertical to Bombay and Jamaica. What is the Sun's declination, and to what places will he be vertical on the 4th August, the 10th September, the 7th May?

XII.—*A place being given in the Torrid Zone, to find on what two days the Sun will be vertical there.*

RULE.—Find the latitude of the place; turn the globe round, and observe what two points of the Ecliptic pass under that degree of latitude. The days on the wooden horizon opposite to these points will be the days required.

Ex.—On what two days is the Sun vertical to Madras? Ans. 24th April and 18th August. On what two days is the Sun vertical at St Helena, at Kingston in Jamaica, at Java, at Manilla?

XIII.—*To find when the Sun is vertical at any given hour.*

RULE.—Find the Sun's declination for the given day, and bring the place to the meridian; set the index to the given hour, and turn the globe till the index points to 12 noon. All the places under the meridian have noon at the given time, and the place whose latitude corresponds with the Sun's declination has the Sun vertical at the given hour.

Ex.—Where is the Sun vertical on the 4th June when it is eight o'clock in the morning at Edinburgh? Ans. A little to the south of Muscat in Arabia. Where is the Sun vertical on the 25th April when it is forty minutes past six o'clock in the morning at London? Where is the Sun vertical on the 18th August when it is four o'clock in the afternoon at London? Where is the Sun vertical on the 18th May when it is twenty minutes past five o'clock in the afternoon at Philadelphia?

XIV.—*To find the Sun's meridian altitude for any day at any particular place.*

RULE.—Rectify the globe for the latitude; find the Sun's place in the Ecliptic, and bring it to the meridian. The number of degrees between that place and the horizon, counted on the meridian, is the altitude required.

Ex.—What is the Sun's meridian altitude at Edinburgh on the 1st of May? Ans. 48°. What is the Sun's meridian altitude at London on the 3d of June, at Paris on the 10th April, at Madrid 6th December, at Quebec on the 4th March, at Lisbon on the 22d June?

XV.—*To find the Sun's altitude at any given place and hour.*

RULE.—Rectify the globe for the latitude, and fix the quadrant in the zenith, that is over the latitude of the place; bring the Sun's place to the meridian, and set the index to 12 noon; turn the globe till the index points to the given hour, and lay the quadrant of altitude over the Sun's place. The number of degrees on the quadrant, counted between the Sun's place and the horizon, is the altitude.

Ex.—What is the Sun's altitude at London on 21st May at nine o'clock in the morning and five o'clock in the afternoon? Ans. For the morning, 43° 30′, for the evening, 24°. What is the Sun's altitude at Rome on the 3d April at nine in the morning and three in the afternoon? What is the Sun's altitude at Madras on the 7th February at ten in the morning and at 30 minutes past two in the afternoon?

XVI.—*To find the Sun's right ascension, oblique ascension, oblique descension, and ascensional difference.*

Rule.—Find the Sun's place in the Ecliptic, bring it to the brass meridian; the degree on the Equator cut by the meridian, reckoning from the point Aries eastward, is the Sun's right ascension.

Elevate the Pole for the latitude of the place, and bring the Sun's place in the Ecliptic to the eastern edge of the horizon, and the degree of the Equator cut by the horizon is the Sun's oblique ascension.

Bring the Sun's place to the western edge of the horizon, and the degree cut by it is the Sun's oblique descension.

Find the difference between the Sun's right and oblique ascension by subtracting the less from the greater, and that is the ascensional difference.

Ex.—What is the Sun's right ascension, oblique ascension, and ascensional difference on the 15th April? Ans. The right ascension is 23° 30′, the oblique ascension is 9° 45′, the oblique descension is 37° 15′, the ascensional difference is 13° 45′.—Ex. What are the Sun's right ascension, oblique ascension, oblique descension, and ascensional difference, on the 27th September, at London?—Ex. What are the Sun's right ascension, oblique ascension, oblique descension, and ascensional difference, on the 1st May, at Edinburgh?

XVII.—*To tell the length of the longest and shortest day in any latitude not exceeding* 66° 30′.

Rule.—Rectify the globe for the latitude; bring the first degree of Cancer to the eastern edge of the horizon, and set the index to 12; turn the globe till the first degree of Cancer touch the western edge of the horizon, and the number of hours that have passed under the meridian is the length of the day. The difference between the length of the day and 24 hours is the length of the night.

Ex.—What is the length of the longest day at Edinburgh? Ans. Nearly 17 h. 30 m. What is the length of the longest day at London, St Petersburgh, Amsterdam, Rome, Lima, &c.?

Note.—To find the length of the shortest day by the globe, bring the first degree of Capricorn to the eastern edge of the horizon, and do as directed for the longest day. The length of the longest and shortest days added together should be 24 hours.

XVIII.—*To find the beginning, end, and duration of twilight at any place on any given day.*

Rule.—Elevate the Pole to the latitude of the given place; bring the Sun's place to the meridian, set the index of the hour-circle to 12, and fix the quadrant in the zenith or over the given latitude; turn the globe westward on its axis till the Sun's place come to the western edge of the horizon, and the hours passed over by the index will show the time of the Sun's setting or the beginning of evening twilight; continue the motion of the globe westward till the Sun's place coincide with 18° on the quadrant below the horizon. The space passed over by the index from the time of the Sun's setting will show the duration of twilight: the morning and evening twilight is the same.

Ex.—What is the duration of twilight at Edinburgh on the 23d September? At what time does dark night commence, and when does twilight begin in the morning? Ans. The Sun sets at six o'clock, and the duration of twilight is two hours; consequently the evening twilight ends at eight o'clock and the morning twilight begins at four. Required the beginning, end, and duration of morning and evening twilight at London on the 25th August?

XIX.—*The day and hour being given when a solar eclipse will happen, to find where it will be visible.*

Rule.—Find the Sun's declination, and elevate the Pole to that declination; bring the place at which the hour is given to the meridian, and set the hour-index to 12; if the given time be before noon, turn the globe westward till the index pass over so many hours as the time wants of noon; if the time be past noon, turn the globe eastward as many hours as it is past noon; then under the Sun's declination you will find the place to which the Sun will be vertically eclipsed. At all places within 70° of this place the eclipse may be visible, particularly if it be a total eclipse.

Ex.—On the 7th September, 1820, there was an eclipse of the Sun, when it was 38 minutes past one o'clock in the afternoon, at London; to what places was it visible? Ans. It was visible to the greater part of Europe, the whole of Africa, the east of North America, and the greater part of South America. On the 12th February, 1831, at 50 minutes past four o'clock afternoon, there was an eclipse of the Sun; where was it visible?

XX.—*The day and hour being given when a lunar eclipse will happen, to find where it will be visible.*

Rule.—Find the Sun's declination as in the last problem. If the declination be north, elevate the South Pole; if south, elevate the North Pole so many degrees above the horizon as are equal to the declination; bring the place at which the hour is given to the meridian, and set the index to 12; then if the given time be before noon, turn the globe westward, if after noon, turn it eastward as many hours as the time may be before or after noon. The place under the degree of the Sun's declination will be the antipodes of that place where the Moon is vertically eclipsed; turn the globe half-round, and to all places above the horizon the eclipse will be visible.

Ex.—There was an eclipse of the Moon on the 15th October, 1818, at 20 minutes past five o'clock in the morning, at Edinburgh; to what places was it visible? Ans. To North and South America, the western kingdoms of Europe, and about the half of Africa on the west. On the 2d October, 1830, there was a total eclipse of the Moon at eleven o'clock evening; where was it visible? On the 6th January, 1833, there will be an eclipse of the Moon at eight o'clock in the morning; where will it be visible?

XXI.—*To find the Antœci, Periœci, and Antipodes of any place.*

Rule.—For the Antœci. Bring the given place to the brass meridian, and observe its latitude; then, in the opposite hemisphere, and under the same degree of latitude, you will find the Antœci.

Rule.—For the Periœci. Bring the given place to the brass meridian, and set the index of the hour-circle to 12, turn the globe till the index points to the other 12, then under the latitude of the given place you will find the Periœci.

Rule.—For the Antipodes. Bring the given place to the brass meridian, and set the index of the hour-circle to 12; turn the globe round till the other 12, then reckon as many degrees south as the given place may be north, and there you will find the Antipodes.

PROBLEMS TO BE SOLVED ON THE CELESTIAL GLOBE.

Signs of the Planets.

☿ Mercury, ♀ Venus, ⊕ the Earth, ♂ Mars, ⚶ Vesta, ⚳ Ceres, ⚴ Pallas, ⚵ Juno, ♃ Jupiter, ♄ Saturn, ♅ Georgium Sidus.

Signs of the Nodes.

☊ Ascending, or North Node; ☋ Descending, or South Node.

I.—*To find the right ascension and declination of a star.*[*]

Rule.—Bring the star to the brass meridian; the degree that stands over it is the declination, and the degree of the equinoctial cut by the meridian is the right ascension.

Ex.—What is the right ascension and declination of Dubhe in the back of the Great Bear? Ans. Right ascension 162° 49′, declination 62° 48′ N. What is the right ascension and declination of the following stars: *Algenib* in Pegasus, *Aldebaran* in Taurus, *Capella* in Auriga, *Rigel* in Orion, *Arcturus* in Boötes, *Procyon* in the Little Dog?

II.—*The right ascension and declination of a star being given, to find its place on the globe.*

Rule.—Bring the given degree of right ascension to the brass meridian, and under the given degree of declination you will find the star.

---

[*] The right ascension and declination of the Moon and planets, with their latitudes and longitudes, are given in the Nautical Almanack.

Ex.—What star has 211° 30′ of right ascension, and 20° north declination? Ans. Arcturus in Boötes. What stars have the following degrees of right ascension and declination?

Right Ascension.	Declination.
7° 19′	55° 26′ N.
25° 54′	19° 50′ N.
53° 54′	23° 29′ N.
83° 6′	34° 11′ S.
76° 14′	8° 27′ S.

III.—*To find the latitude and longitude of any star.*

Rule.—Place the upper end of the quadrant of altitude on the North or South Pole of the Ecliptic, as the star may be on the north or south side of it; move the other end of the quadrant till the graduated edge comes over the centre of the star. The number of degrees contained between the Ecliptic and the star is the latitude; the number of degrees between the first point of Aries and the edge of the quadrant is the longitude.

Ex.—Required the latitude and longitude of Aldebaran in Taurus? Ans. Latitude 5° 28′ S.; longitude 2 signs* 6° 53′, or 6° 53′ Gemini. Required the latitudes and longitudes of the following stars: *Markab* in Pegasus, *Altair* in the Eagle, *Vega* in Lyra, *Fomalhaut* in the S. Fish, *Scheat* in Pegasus.

IV.—*The latitude of a place, day of the month, and the hour being given, to place the globe in such a manner that it will represent the face of the heavens at that time.*

Rule.—Set the globe due north and south, and rectify it for the given latitude and Sun's place; turn the globe till the index points to the given hour, and in this position the globe will represent the face of the heavens. If the situation of the planets is wanted, find their latitudes and longitudes in a nautical Almanack, and mark their places on the globe.

Ex.—Represent the face of the heavens for Edinburgh on the 25th December, at half-past 9 o'clock, and Cor Leonis will be found 10° high, E. by N. Procyon is 23° E.S.E. Capella is about 75° S.E. Sirius, about 8°. Aldebaran, 48° high, a little to the east of the meridian. Orion, one of the most conspicuous constellations in the heavens, between Sirius and Aldebaran. Algenib to the west of the meridian, and nearly 84° high.

V.—*To find at what time any of the heavenly bodies will rise, come to the meridian, and set on any given day.*

---

* Signs signify the signs of the Ecliptic. Aries 1, Taurus 2, Gemini 3, Cancer 4, &c.

RULE.—Rectify the globe for the latitude and Sun's place for the given day; bring the star or planet's place, found in the Nautical Almanack, to the eastern edge of the horizon, the index will show the hour of rising; then take the star to the meridian, the time of culminating will appear on the index. Bring the star to the western edge of the horizon, and the index will point the time of setting.

Ex.—At what time will Arcturus rise, come to the meridian, and set at London? Ans. It will rise at seven o'clock in the morning, come to the meridian at three in the afternoon, and set at eleven o'clock at night. At what time does Aldebaran rise, culminate, and set at Edinburgh on the 20th January? At what time does Sirius rise, set, and come to the meridian of Edinburgh, on the 30th January? At what hour will Jupiter rise, culminate, and set at London on the 12th of December, 1831, his longitude being then 10 signs, 13° 23′, or in 13° 23′ of Capricorn, and his latitude 59′ S.?

NOTE.—Find the planet's place, and put a small patch of paper on the globe.

VI.—*To find the amplitude of any star, and the length of its diurnal arc at any place.*

RULE.—Rectify the globe for the latitude of the given place; bring the given star to the eastern edge of the horizon, the number of degrees contained between the east point of the horizon and the star is the amplitude required, either north or south. Set the hour-index to 12, and turn the globe till the star come to the western edge of the horizon, the hours passed over by the index will be the star's diurnal arc.

Ex.—Required the rising and setting amplitude and diurnal arc of Sirius at London? Ans. The rising amplitude is 27 degrees to the south of the east; the setting amplitude, 27 degrees south of the west; and the diurnal arc, 9 hours six minutes. Required the amplitude and diurnal arc of Bellatrix at Paris?

VII.—*To find the distance of the stars from each other in degrees.*

RULE.—Lay the graduated edge of the quadrant over the given stars; the degrees, counted on the quadrant between the two stars, is the distance required.

Ex.—Required the distance between Capella and Cor Hydræ. Ans. 79°. What is the distance between Aldebaran and Sirius? Between *Arcturus* in Boötes and the star β in the right shoulder of Serpentarius? Between *Vega* in Lyra and *Altair* in the Eagle.*

---

* None of these distances is to be understood as real; for that no

VIII.—*The latitude of a place and day of the month being given, to find the meridian altitude of any star or planet.*

Rule.—Elevate the Pole to the latitude of the place and bring the star to the brass meridian; the degrees contained on the meridian between the horizon and the star is the altitude required.—For the Moon or a planet Find its latitude and longitude for the given month and day, and bring it to the brass meridian; the number of degrees between the horizon and the planet is the altitude required.*

Ex.—What is the meridian altitude of Procyon in the Little Dog in the latitude of Edinburgh? Ans. 44°. What is the meridian altitude of Arcturus in Boötes at Edinburgh? Of Sirius at London? Of Aldebaran at Rome? Of Capella at Lisbon?—On the 1st of September, 1823, the longitude of Mars was 10 signs 2° 20′, and latitude 5° 48′ S.; what was his meridian altitude at London?

IX.—*The latitude and day of the month being given, to find whether Venus is a morning or an evening star, and how long she rises before the Sun, or how long she is after the Sun in setting.*

Rule.—Find the latitude and longitude of Venus in the Nautical Almanack, and mark her place on the globe, then rectify the globe for the latitude and Sun's place for the given day. If Venus be then to the right hand of the meridian, she is an evening star; if to the left, she is a morning star.

When Venus is an Evening Star.—Bring the Sun's place to the western edge of the horizon, and set the index of the hour-circle to 12. Turn the globe westward on its axis till Venus comes to the edge of the horizon; and the hours passed over by the index will show how long Venus is above the horizon after the Sun.

When Venus is a Morning Star.—Bring the Sun's place to the eastern edge of the horizon, and set the

---

one can tell, much less are they capable of being reduced to miles, but only as they appear to us under their different situations.

* Here the day of the month need not be attended to, as the meridian altitude of the stars on the globe in the same latitude is invariable; but as the planets are continually changing their situation, it is necessary to have the day for them.

index of the hour-circle to 12. Turn the globe eastward on its axis till Venus comes to the eastern edge of the horizon; and the hours passed over by the index will show how long Venus rises before the Sun.

NOTE.—The same rule will serve for Jupiter, by marking his place instead of that of Venus.

EX.—On the 12th August, 1829, the longitude of Venus was 4 signs 4° 32′, or 4° 32′ of Leo, and her latitude 41′ N., Was she a morning or an evening star? Ans. Venus was a morning star, and rose about one hour and forty-five minutes before the Sun. On the 25th December, 1831, the longitude of Jupiter will be 10 signs 21° 11′, or 21° 11′ in Aquarius, and his latitude 0° 55′ S., Will he be a morning or an evening star?

EXPLANATION OF TERMS MADE USE OF IN ASTRONOMY.

Aberration, an apparent change of place in the fixed Stars, which arises from the motion of the Earth combined with the motion of light.

Æras, certain periods of time whence *Chronologers and Astronomers* begin their computation.

Angle, the inclination or opening of two lines meeting in a point.

Antipodes, those inhabitants of the Earth who live diametrically opposite to each other.

Aphelion, that point in the orbit of a planet in which it is at its greatest distance from the Sun.

Atmosphere, that collection of vapours or body of air which surrounds or encompasses the Earth.

Attraction, a property of nature by which bodies are made to approach each other without any sensible agent either drawing or impelling them.

Axis of the Earth, or a planet, an imaginary line passing through the centre from one Pole to the other, or that round which they are supposed to perform their diurnal rotations.

Bissextile or *Leap Year*, so called by the Romans on account of their reckoning the 6th day of the *Calends* of March twice over.

Centrifugal Force, that force by which any revolving body endeavours to fly off from the centre of motion, in a tangent, to the circle which it describes.

Centripetal Force, that force by which any revolving body is made to tend towards the centre of its orbit.

Colures, two great circles or meridians, one of which passes through the *solstitial points*, Cancer and Capricorn, and the other through the *equinoctial points*, Aries and Libra.

Conjunction is when two Stars, seen from the Sun or Earth, appear in the same point of the heavens, or answer to the same degree of the Ecliptic.

Constellation, a group of Stars resembling some figure.

Day, Natural, that portion of time in which the Earth completes an entire revolution on its axis.

—— *Artificial*, the time between the Sun's rising and setting.

—— *Astronomical*, the time between the successive transits of the Sun's centre over the same meridian, which always begins and ends at noon.

Declination of the Sun, Moon, or Stars, is the distance north or south of the Equator.

Diurnal, daily.—*Direct*, moving straight forward from west to east, opposed to retrograde.

Eccentricity, the difference or deviation from a true circle.

Ecliptic, a great circle of the sphere in which the Sun always appears to move; so called because eclipses generally happen when the Moon is in or near this circle.

Elongation, the angular distance of a planet from the Sun as it appears to the spectator on the Earth.

Equator, a great circle that divides the northern from the southern hemispheres.

Equinoxes, the two points when the Ecliptic cuts the Equator; so called because the days and nights are of equal length.

Horizon, Sensible, the boundary of our sight.

——— *Rational*, a great circle which is parallel to the sensible horizon, and whose two poles are the zenith and nadir.

Latitude of a place, its distance from the Equator north or south, reckoned in degrees, minutes, &c., upon the arc of a great circle which is perpendicular to it.

Longitude of a Star or Planet is its distance from the 1st point of Aries, reckoned in degrees, minutes, &c., upon the Ecliptic.

Luminous, light. *Luminary*, *Sun* or *Moon* is called a luminary.

Nadir, that point of the heavens directly over our head.

Nebulae, clusters of small Stars, so called from their cloudy appearance.

Nodes, the two points where the orbit of a planet intersects the plane of the Ecliptic.

Nucleus, any thing about which matter is conglobated or gathered.

Occultation is when a Star or planet is hid from our sight by the interposition of the Moon or some planet.

Opaque, dark, not transparent.

Parallax, the difference between the places of any celestial object as seen from the surface of the Earth and from its centre.

Physical, relating to nature or to natural philosophy.

Perihelion, that point of a planet's orbit which is nearest the Sun.

Precession of the *Equinoxes*, a slow motion of the two points where the Equator intersects the Ecliptic, which are found to go backward about fifty-two seconds per year.

Projectile, any body put in motion.

Quiescent, a body at rest, opposite to motion.

Retrograde, going backward.

Sideral, belonging to the Stars or Planets.

Solar, belonging to the Sun.

System, a number of bodies revolving round a common centre, as the planets and comets move round the Sun.

Syzygies, the conjunction and opposition of the Moon particularly.

Tropics, two small circles of the sphere at which the Sun turns his course. They are parallel with the Equator, and are nearly twenty-three and a half degrees distant from it.

Zodiac, a zone or girdle surrounding the heavens, of about 18 degrees broad, in the middle of which is the Ecliptic, and in which the orbit of all the planets are included.

THE END.

Oliver & Boyd, Printers.